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Mark Schipper

Energy Information Administration

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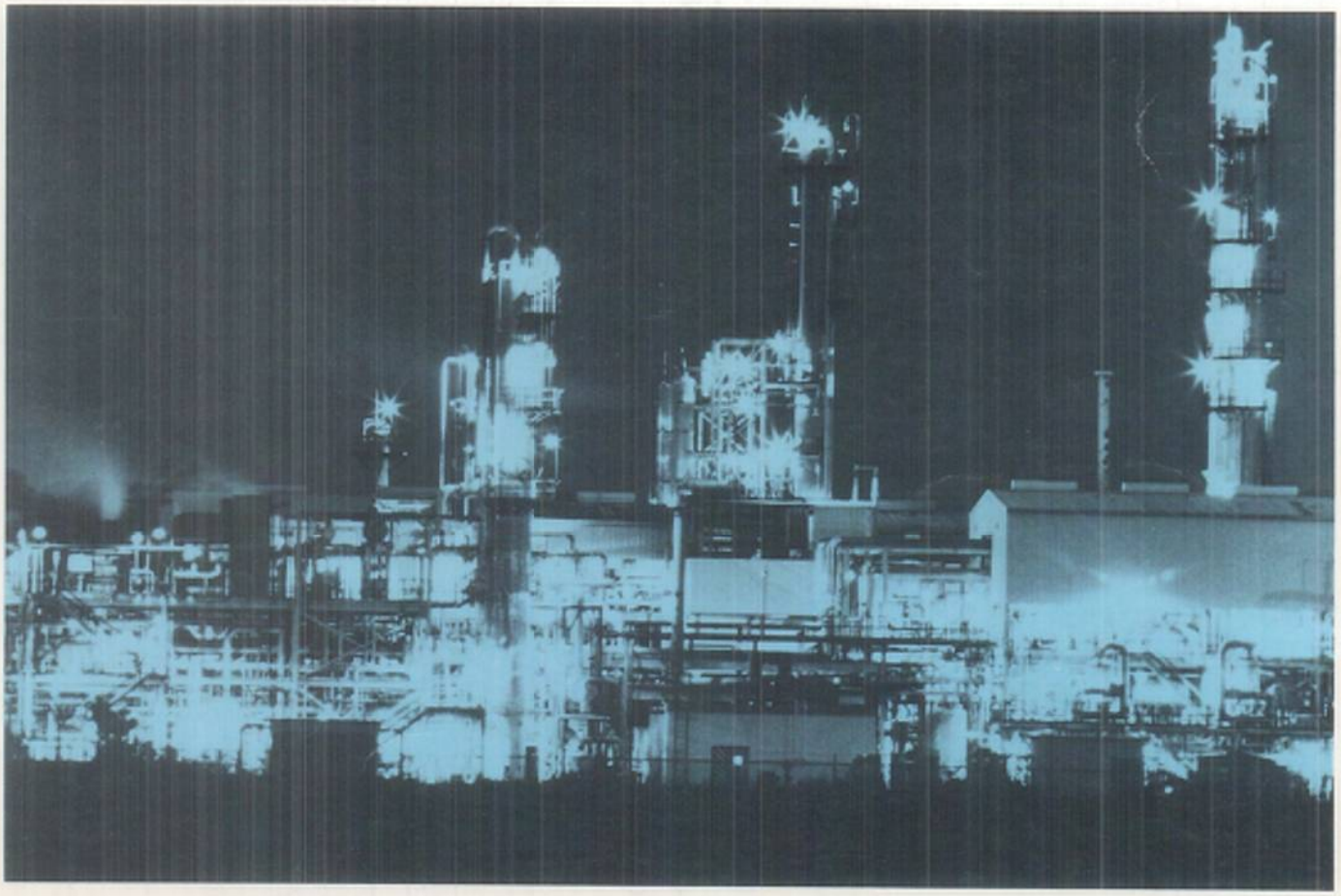
Manufacturing Energy Consumption Survey: Fuel Switching, 1985



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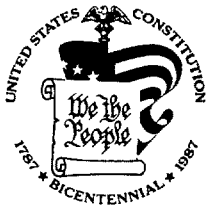

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Manufacturing Energy Consumption Survey: Fuel Switching, 1985

Energy Information Administration
Office of Energy Markets and End Use
U.S. Department of Energy
Washington, DC 20585

Contacts

General information about Energy Information Administration data on fuel-switching capabilities can be obtained from Lynda T. Carlson, Director of the Energy End Use Division (202/586-1112).

Specific information regarding the contents or preparation of this publication can be obtained from Dwight K. French, Chief of the Transportation and Industrial Branch (202/586-1126) or John L. Preston, Team Leader (202/586-1128). Robert K. Adler (202/586-1134) and Jean Pannanan (202/586-1800) are the contacts for analysis and table preparation. Hattie Ramseur (202/586-1124) is the contact for related energy consumption publications. Gerald E. Peabody, Office of Energy Markets and End Use provided substantially to the text of the report.

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1. Introduction

The Manufacturing Energy Consumption Survey (MECS) provides comprehensive data on energy use by manufacturing industries in the United States, including their fuel-switching capabilities. The impact on manufacturing production of an interruption in the supply of a particular fuel can be mitigated if manufacturers have the capability to switch to alternate fuels. Similarly, in a period of substantial changes in the relative prices of fuels, manufacturers that can switch to less expensive fuels will have an economic advantage. Information about the ability of manufacturing establishments to switch to alternative fuels provides valuable information for assessing the Nation's vulnerability to supply disruptions and the effects on manufacturers of other changes in energy markets.

This report is the second data report based on the 1985 MECS. It provides information on the fuel-switching capabilities of manufacturing industries in the United States. The first report, *Manufacturing Energy Consumption Survey: Consumption of Energy, 1985*, presented a comprehensive description of energy consumption by manufacturing industries.[1] The MECS covers all manufacturing industries. Not included in this report are mining, agriculture, construction and electric utilities.

The 1985 MECS was conducted under the authority of the Federal Energy Administration Act of 1974, Public Law 93-275, as amended. Subsequent surveys will be conducted every three years under the authority of Section 310(a) of the Omnibus Budget Reconciliation Act of 1986, Public Law 99-509. The Industry Division of the Bureau of the Census serves as Energy Information Administration's collection and compiling agent for the MECS. All reports submitted to the Bureau of the Census are confidential under the provisions of Section 9, Title 13, of the U.S. Code.

Fuel-Switching Capability

The MECS provides data on the capability of manufacturing establishments to adjust the mix of fuels they used in 1985 without affecting their production. The fuel-switching capability measured by MECS is limited to short-term fuel changes. The establishment must have been capable of changing fuels within 30 days, using only existing equipment and keeping production output constant. Fuel-switching capability was determined for all energy used for the production of heat and power and the generation of electricity. (See Appendix A for a complete description of the concept of fuel-switching capability used in MECS and how it was measured.)

Energy consumers can adapt to changes in economic conditions, supply disruptions, and other constraints on energy use by having the capability to use more than one fuel to meet their energy needs. For example, a household with a central furnace may also have a wood stove that can assume part or all of the heating load for the house. Hospitals commonly have emergency backup generators fired by oil or gas which they use to provide electricity during a power outage.

In-place capability to substitute one fuel for another is especially prevalent in the manufacturing industries. Some manufacturers use combustors that are able to burn two or more different fuels simultaneously, in varying mixtures, to produce the desired heat output. Others have equipment that can burn only one fuel at a time, but that can be easily converted, within hours or at most days, to burn a different fuel. Still other establishments have multiple combustors that use different fuels to supply heat or power for the same purpose. Ordinarily, not all combustors are required to operate at full capacity to meet heat or power requirements. Thus, these establishments can alter their energy mix by changing the combustors that are in use.

Fuel-switching capability was determined for five major types of energy: purchased electricity, natural gas, residual fuel oil, distillate fuel oil, and coal/coke. For each of these fuels, switching capability was measured relative to 1985 consumption. The MECS first determined how much consumption could have been switched to one or more alternative fuels. Then, for each possible alternative, the MECS determined how much consumption of the switchable fuel could have been replaced by each alternative. Data on the total quantity of each of the five major fuels that could be

[1]Energy Information Administration, *Manufacturing Energy Consumption Survey: Consumption of Energy, 1985* (DOE/EIA-0512(85) (Washington, DC, November 1988).

switched are presented in this report, along with the quantities that could be switched to each of the alternative fuels.

The amounts of switchable consumption were used to derive the minimum and maximum potential consumptions of the five major energy types that could have occurred had fuel switching taken place. The minimum value for a given energy type represents its actual 1985 consumption less its total switchable consumption. The maximum value represents actual consumption plus the total consumption that could be switched to it if all possible switching from the other fuels took place. The difference between the maximum and minimum consumption is the amount of discretionary consumption for the fuel--the consumption from which manufacturers could choose what proportion to consume.

Distillate fuel oil and residual fuel oil had the largest ratios of maximum to minimum potential consumption, indicating that these fuels had a substantial fuel-switching capability. However, most manufacturers in 1985 chose to use other fuels, so the actual consumption levels for the fuel oils were close to their minimum potential values. This is illustrated in Figure 1, where the heights of columns are scaled to annual amounts in common units (quads). By contrast, natural gas had the largest amount of discretionary consumption, not unexpectedly since it was the fuel consumed most heavily by manufacturers. In 1985, most manufacturers that could use natural gas did so. Consequently, actual consumption of natural gas was close to the maximum possible.

In addition to measuring the amounts of fuel switchable to various alternatives, the MECS also collected data on the minimum leadtime needed to switch to the primary alternative (the alternative that accounts for the largest proportion of switching capability). These data break down the 30-day allowable switching period into three shorter periods: less than 1 day, 1 day to 1 week, and over 1 week. Based on available leadtime data, conversion time periods have been assigned to most, but not all, switchable consumption. In the few instances where the leadtime was not reported, the switchable consumption has been assigned to the category "leadtime not ascertained". Typically, about one-half the switchable energy could be converted within 1 day, and at least three-fourths in less than 1 week.

The Fuel-Switching component of MECS was conducted before all responses were received from the main energy consumption survey. Consequently, it was not possible to ascertain for all the consumption measured in MECS whether the energy could be switched to an alternative. The amount of consumption for which switching capability could not be ascertained varied with the fuel type. The data in the Detailed Statistics Tables give the total consumption of each fuel measured in MECS (including the consumption for which switching capability was not ascertained), the amounts of consumption ascertained to be switchable, and the amounts ascertained to be not switchable. See Appendix A for a complete discussion of the procedures followed in conducting the Fuel-Switching component of MECS and the relation between the Fuel-Switching sample of MECS and the sample for measuring energy consumption.

It should be emphasized that the data on fuel-switching capabilities presented in this report are the limits on the extent to which manufacturers could quickly switch to alternate fuels if they decided to do so. These capabilities depend upon equipment characteristics and other practical constraints, such as binding supply contracts, interruptible service, environmental regulations, or unavailability of supply or delivery systems for a potential alternate fuel. The MECS data provide no information on the circumstances that might induce manufacturers to switch fuels, nor on the portion of the fuel-switching capability that might be implemented should a switch be made.

Surveying the Manufacturing Sector

The Manufacturing Sector Consists of Business Establishments that Produce Goods

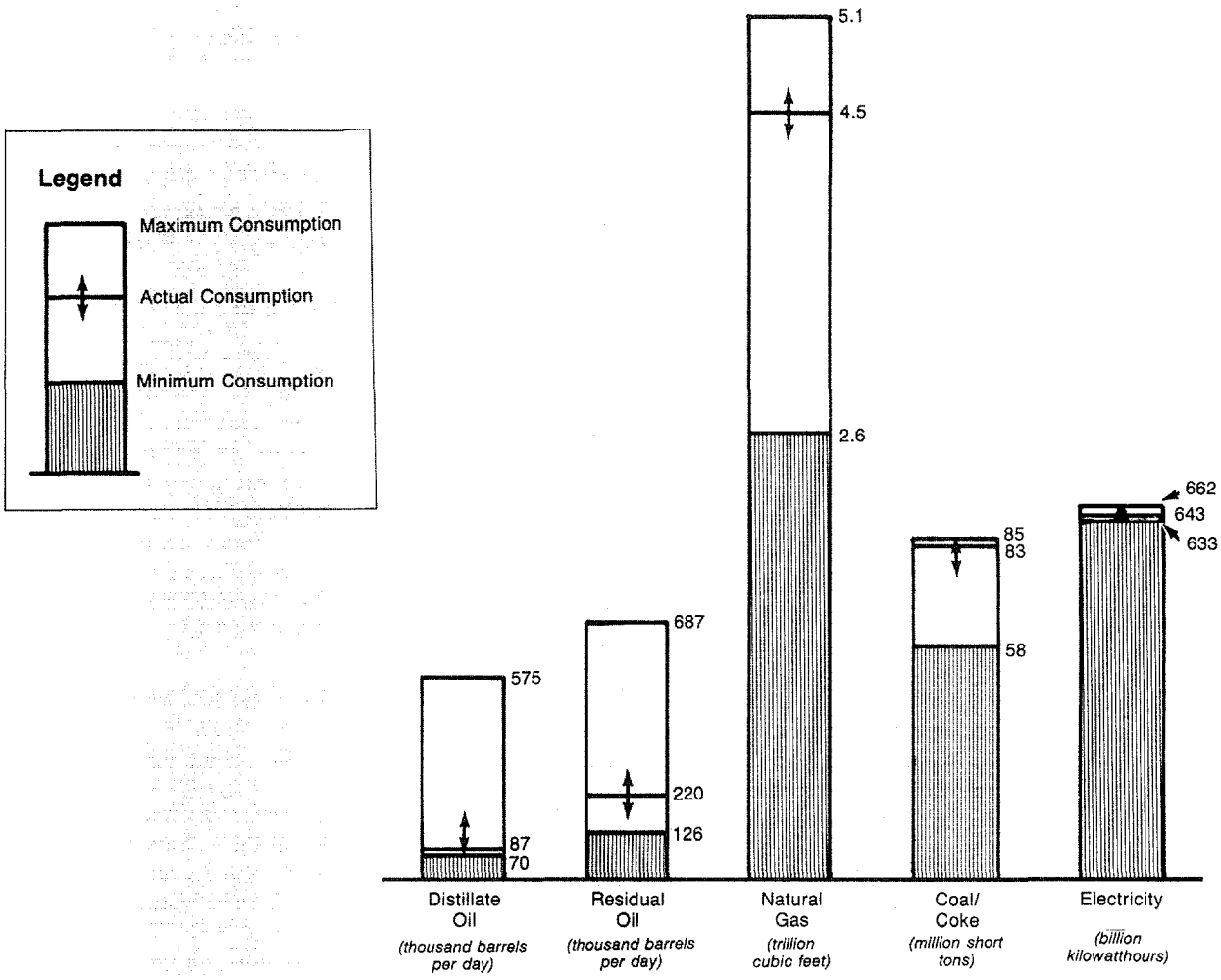
The manufacturing sector is composed of establishments that transform material or substances into new products using mechanical or chemical processes. These products may be final products that consumers will purchase, such as an automobile or a chair. Manufacturers also produce intermediate goods that will be used by other manufacturers, such as parts for automobile engines or rolls of upholstery fabric.

An establishment is generally at a single location and is often referred to as a plant, factory, or mill. It ordinarily uses power-driven machines and equipment for handling materials. A manufacturing establishment may also assemble components or perform blending operations. Electric utilities, mining operations, agriculture, and construction are not included in the manufacturing sector.

Establishments are classified into industry categories based on the system of Standard Industrial Classification (SIC) developed by the Office of Management and Budget.[2] Each establishment is placed into the category associated with the type of good it produces.

[2]Office of Management and Budget, *Standard Industrial Classification Manual, 1972* (Washington, DC, 1982).

Figure 1. 1985 Fuel Consumption and Switching Capability



Potential Consumption					
Maximum	575	687	5.1	85	662
Minimum	70	126	2.6	58	633
Discretionary Range	505	561	2.5	27	30
1985 Status					
Actual Consumption	87	220	4.5	83	643
Potential Change through Switching:					
Increase	488	467	0.6	2	19
Decrease	17	94	1.9	25	11

Notes: •Totals may not equal sum of components due to independent rounding.
•Heights of columns are scaled to annual amounts in common units (quads).

Source: Energy Information Administration, Form EIA-846(S), "1985 Manufacturing Energy Consumption Survey. Part II - Fuel Switching Capability."

If an establishment manufactures more than one kind of good, it will be classified according to its primary product. For example, an establishment that is primarily engaged in manufacturing paper from wood pulp, but that also manufactures some paperboard, would be classified as a Paper Mill (SIC 2621). It would not also be classified as a Paperboard Mill (SIC 2631).

MECS Samples Establishments in All the Major Manufacturing Groups and the Most Energy-Intensive Industries

The estimates in this report are based on data collected from a carefully designed sample of manufacturing establishments. Several important considerations were included in the criteria for the design of the sample. First, the sampling procedures ensured that all manufacturing establishments were represented. Second, specific industries that have been heavy users of energy in the past were individually sampled to ensure their inclusion in the survey. Also, the size of the sample in each industry group was controlled so that the error levels of the survey estimates would be similar for each group.

The MECS sample was selected as a subset of the mail sample for the Annual Survey of Manufactures (ASM), conducted by the Bureau of the Census. The ASM mail sample is comprised of 56,000 manufacturing establishments drawn from the approximately 225,000 establishments in the Census of Manufactures mail file. A sample of about 12,000 establishments from the ASM was used for MECS. (See Appendix A for a detailed discussion of the procedures followed to determine the MECS sample.) Establishments were selected from each of the 20 major industry groups (2-digit SIC code) that together make up the manufacturing sector. In addition, establishments were selected from 10 specific industries (4-digit SIC code) that historically have consumed the most energy. Appendix D contains a description of these 30 groups.

This report presents estimates of fuel-switching capability for subgroups of the manufacturing sector. These estimates are based on data that MECS collected from individual manufacturing establishments. The MECS collected data on the consumption of energy that manufacturing establishments use for all purposes, including the production of heat and power, generating electricity, and raw material inputs. The specific MECS data that are reported here are based on consumption that was used for the production of heat and power or for generating electricity. The fuel-switching data specify the amount of consumption that could have been replaced by alternate fuels, and the amounts of potential consumption of these alternatives. None of these data have been collected for energy consumed for a specific activity. The fuel-switching estimates reported in this publication are for all establishments within an industrial group. No estimates are provided on fuel-switching capability for energy consumed to carry out a specific activity. In the previous example, the fuel-switching capability for the paper mill--for all its operations--would be included in the data for Paper Mills. Even if the establishment were able to switch fuels used to produce paperboard, this fuel-switching capability would be assigned to Paper Mills.

Overview of the Findings

Approximately 92 Thousand Barrels per Day of Petroleum Fuels Were Switchable to Other Fuels by Manufacturing Industries During 1985

In 1985, manufacturers consumed 307 thousand barrels per day of residual and distillate fuel oils to produce heat and power and to generate electricity (Table S1). Because of their capability to consume other fuels in place of petroleum fuels, manufacturers could have switched about 92 thousand barrels per day of distillate and residual fuel oil consumption to nonpetroleum fuels--natural gas, purchased electricity, coal/coke, and other nonpetroleum. Thus, manufacturers could have lowered their consumption of petroleum fuels to about 215 thousand barrels per day and maintained their production at 1985 levels. (See Box.)

The figure of 92 thousand barrels per day is approximate for two reasons, apart from the uncertainty associated with sampling error. (See Appendix B for a discussion of the effects of sampling variability on the results contained in this report.) First, a small amount of the petroleum fuel can be replaced by more than one nonpetroleum fuel. However, summing the amounts switchable to each of the alternatives to arrive at the 92 thousand figure assumes there is no redundancy. This small redundancy, which is inherent in the way the data were collected, gives a slight overestimate of the amount of petroleum fuels switchable to nonpetroleum fuels. Second, fuel-switching capability could not be ascertained for about 12 percent of petroleum consumption. Presumably some of this consumption could have been switched to nonpetroleum energy, and the exclusion of this switchable fuel gives an underestimate of the total consumption that could have been switched from petroleum fuels. These two factors offset each other, and their net contribution to the estimate's uncertainty is not likely to be larger than that of the sampling error.

Consumption of natural gas was 4.5 trillion cubic feet (Tcf) in 1985 to produce heat and power and to generate electricity. If all possible switching out of natural gas had taken place, consumption would have been lowered by 1.9 Tcf, a 42 percent reduction. About 30 percent of the 83 million short tons (1.8 quads) of coal and coke consumed in 1985 could have been switched. Manufacturers consumed a comparable amount of elec-

tricity, 643 billion kWh or 2.2 quads, but only a small portion of this consumption was switchable to another fuel. About 2 percent of electricity consumption, 10.6 billion kWh, could have been switched to other fuels.

Natural Gas Was the Dominant Alternative Fuel Had Manufacturers Switched from Oil

Natural gas was the fuel that could have replaced the largest amounts of distillate and residual fuel oil consumption in 1985 had manufacturers switched from petroleum fuels. Seventy-three percent of the switchable residual fuel oil consumption and 67 percent of the switchable distillate consumption could have been switched to natural gas. The fuels that could have replaced the second largest amounts of each fuel oil was the other fuel oil. Distillate fuel oil could have replaced 31 percent of the switchable residual fuel oil consumption, while residual could have replaced 21 percent of the switchable distillate consumption.

Natural gas could also have replaced the largest portions of coal/coke and electricity consumption that were switchable in 1985. Natural gas could have replaced 67 percent of switchable coal and coke consumption and 70 percent of switchable electricity consumption. Petroleum fuels were the dominant alternatives for natural gas in 1985. Residual and distillate fuel oil could each have replaced about one-third of the natural gas consumption that could have been switched.

Low Oil Consumption Reflects Preference for Natural Gas and Coal/Coke by Manufacturers in 1985

The relative consumption levels of different fuels in 1985, and the amount of each fuel that could be switched, in part reflects choices made on what fuels to consume where choices were available. In 1985, manufacturers that could use natural gas or coal/coke generally choose to do so. On the other hand, petroleum fuels were generally used only when no alternative was available.

Petroleum Fuel Consumption Switchable from Petroleum in 1985

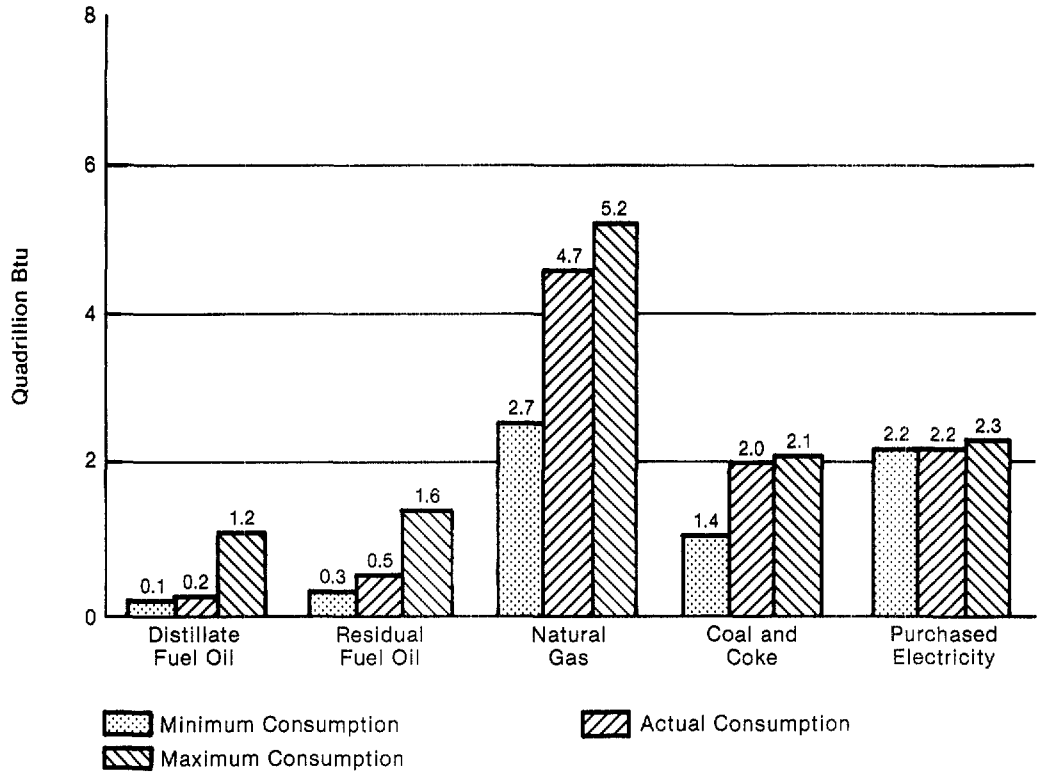
(Thousand Barrels per Day)

	Distillate Fuel Oil	Residual Fuel Oil	Total Petroleum
Total Consumption	87	220	307
Switchable from Petroleum	13	79	92
Alternative Fuel:			
Natural Gas	11.4	68.3	80
Purchased Electricity	0.9	2.8	4
Coal/Coke	0.5	3.7	4
Other Nonpetroleum	0.2	4.3	4

If manufacturers had substituted natural gas for other fuels wherever possible, natural gas consumption would have been 5.1 Tcf (5.2 quads), slightly higher than the actual consumption of 4.5 Tcf. If establishments had switched from using natural gas whenever it was possible to do so, consumption would have been 2.6 Tcf (2.7 quads). Thus, natural gas consumption in 1985 was bracketed by a lower bound of 2.6 Tcf and an upper bound of 5.1 Tcf (Figure 2).

The lower bound of natural gas consumption, 2.6 Tcf, can be considered the potential minimum level of consumption. Manufacturers could not have reduced their consumption of natural gas below this amount and still

Figure 2. Minimum, Actual, and Maximum Energy Consumption by Manufacturers for 1985



Source: Energy Information Administration, Form EIA 846(S), "1985 Manufacturing Energy Consumption Survey."

maintained the production levels observed in 1985. The difference between the minimum consumption and the upper bound of consumption is the amount of discretionary consumption, 2.5 Tcf (2.5 quads). Manufacturers could choose to consume some portion of this discretionary consumption, depending upon economic and other factors. The total 1985 consumption of 4.5 Tcf represents the 2.6 Tcf minimum consumption plus 1.9 Tcf (2.0 quads) of discretionary consumption. Manufacturers chose to consume 76 percent of the possible discretionary consumption, indicating that natural gas was frequently the fuel of choice when manufacturers had the flexibility to choose it.

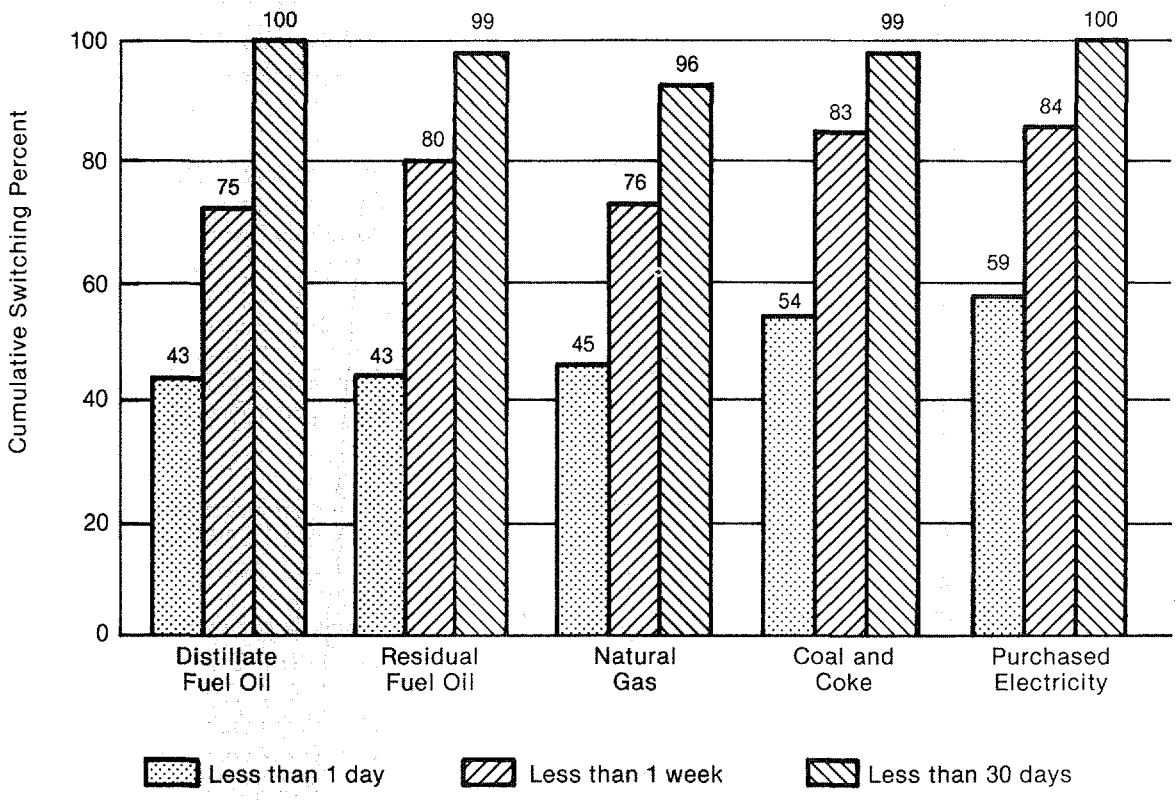
The relative amounts of minimum and discretionary consumption varied substantially among the different fuels. (Table S1 presents estimates of minimum consumption and maximum consumption, along with actual consumption for 1985 for the various fuels.) Manufacturing establishments in 1985 consumed a total of 31.7 million barrels (0.2 quads) of distillate fuel oil. The minimum consumption was 25.4 million barrels (0.1 quads), while the upper bound of possible consumption if all possible users switched to distillate was 210.0 million barrels (1.2 quads). Thus, discretionary consumption was 184.6 million barrels (1.1 quads), over 7 times as much as the minimum consumption. (This compares with natural gas where the minimum consumption and the total discretionary consumption were about equal.)

The consumption of 31.7 million barrels (0.2 quads) of distillate was 6.2 million barrels (0.04 quads) above the minimum consumption. The consumption of 6.2 million barrels of discretionary consumption was less than 4 percent of the total discretionary consumption. For the most part, then, manufacturers used distillate in 1985 only when there was no alternative fuel they could switch to.

A similar situation existed for residual fuel oil. Manufacturing establishments consumed a total of 80.3 million barrels (0.5 quads) of residual fuel oil in 1985. The minimum consumption, the amount that could have been consumed if all users switched to other fuels whenever possible, was 46.1 million barrels (0.3 quads). The maximum consumption, if all potential users switched to using residual fuel oil, was 250.9 million barrels (1.6 quads), giving a discretionary consumption of 204.8 million barrels (1.3 quads). Manufacturers consumed 34.2 million barrels (0.2 quads) over the minimum consumption, which represented about 17 percent of the total discretionary consumption possible.

For coal and coke, the situation was the reverse. Almost all of the discretionary consumption was, in fact, consumed. The total 1985 consumption of coal and coke was 83.0 million short tons (1.8 quads). The minimum consumption was 58.1 million short tons (1.3 quads), and the maximum possible consumption was

Figure 3. Cumulative Percent of 1985 Switchable Energy Consumption by Manufacturers (Time Required to Switch)



Source: Energy Information Administration, Form EIA 846(S), "1985 Manufacturing Energy Consumption Survey."

85.3 million short tons (1.9 quads). Discretionary consumption of coal and coke was 27.2 million short tons (0.6 quads), of which 92 percent, 24.9 million short tons (0.5 quads), was actually consumed. This high percentage indicates that coal and coke was the most popular fuel among those manufacturers that had the capability to use it.

Purchased electricity had the narrowest range of discretionary consumption of all the sources of heat and power. Manufacturers consumed a total of 643.3 billion kilowatthours (kWh) in 1985, the equivalent of 2.20 quads. They could have reduced consumption to 632.7 billion kWh (2.16 quads) or increased it to 662.3 billion kWh (2.26 quads) through switching capability. Discretionary consumption amounted to only 29.6 billion kWh (0.10 quads). Manufacturers consumed 36 percent of the discretionary electricity that was possible.

Manufacturers Could Implement One-Half of Fuel Switching Within a Few Hours

The fuel-switching capability considered in this report is for switches that could be made in a short amount of time. Given enough time and money, manufacturers can replace most any fuel. However, the focus of this report is on changes that do not require major modifications to, or the replacement of, existing energy-consuming equipment. Table 2 of the Detailed Statistics Tables section presents statistics on the quantities of fuel that could be switched within minimum leadtimes.

The short-term capability to switch to alternative fuels represents the extent to which energy consumers could respond to emergency situations, to changes in the relative prices of fuels, or to other factors. The fuel-switching capability estimates in this report are short-term capabilities. That is, the change in fuel used could be implemented within 30 days.

In an emergency situation, even 30 days is a long time period. The ability to respond to an emergency is considerably enhanced if a fuel can be replaced within a few hours from the time the decision to do so is made. About 50 percent of the quantity of fuel that was switchable could have been replaced within one day (Figure 3). The portion of fuel that could be switched within 1 day depended upon the type of fuel, ranging from 43 to 59 percent. From 75 to 84 percent of the switchable fuel could have been replaced within 1 week.

Slightly more than one-half of the electricity and of the coal and coke that could be switched was replaceable within one day. For electricity, 59 percent of the

switchable consumption could be replaced in 1 day, although only a small amount of electricity consumption was replaceable. Of the switchable coal and coke, 54 percent could be replaced in 1 day. Natural gas and the fuel oils had longer switching periods. From 43 to 45 percent of these fuels that could be switched were switchable within 1 day. For natural gas and distillate fuel oil, the cumulative percent of consumption that could be switched within 1 week was 76 and 75 percent, respectively. For the other fuels, at least 80 percent could be switched within 1 week.

Multiple Alternative Fuels Provide Flexibility in Fuel Use

The flexibility that a manufacturer has in switching fuels is a function of the number of other fuels that could serve as a replacement for a given fuel used for a specific purpose. The MECS provides an indirect measure of this flexibility. The data in Tables 3 through 7 of the Detailed Statistics Tables section include the amount of a given fuel used to produce heat and power that is switchable, and the quantities of that fuel that could be replaced by specific alternatives. A measure of the flexibility available in choosing among alternative fuels is provided by adding the alternative fuel quantities and comparing this total with the total switchable quantity. To the extent that the sum of the quantities of alternative fuels that could be consumed is larger than the quantity of fuel that can be replaced, there is flexibility in the choice of alternative fuels. If the totals are about the same, there is little flexibility in the choice of alternative fuels.

To understand why comparing these two totals indicates the degree of fuel-switching flexibility, it is useful to consider several specific examples of switching situations. A manufacturer using a boiler that can burn one of two possible fuels and has no other switching capability, has no flexibility in choosing alternative fuels. One fuel or the other must be chosen. In this case, the total quantity of switchable fuel consumed is equal to the quantity of the single alternative fuel that could be consumed.

Next, consider a manufacturer with several essential boilers, all of which are dual-fired, with different boilers having different combinations of fuel pairs. This case is very similar to the first. The manufacturer has more fuels to choose from in switching fuels, but only a portion of the total boiler consumption can be switched to a given alternative fuel. Since each boiler can be fired by only one of two possible fuels, the total quantity of switchable fuel consumed will equal the sum of the quantities of alternative fuels that could be consumed as replacements.

However, a manufacturer that has boilers that can all be fired by four different fuels will have considerable flexibility in fuel-switching decisions. In this case, the sum of the quantities of consumption switchable to the alternative fuels will be three times the consumption of the fuel being consumed that is switchable.

Electricity is the Most Flexible Switchable Fuel, Followed by Natural Gas

The fuel used as a source for heat and power that has the most flexibility for switching is electricity (Figure 4). The sum of the amounts of electricity switchable to its various alternatives is 18.2 billion kWh (0.062 quads), which is 71 percent larger than the 10.6 billion kWh (0.036 quads) of electricity consumption that can be switched. The advantage of this flexibility is severely limited, however, by the fact that only 2 percent of total purchased electricity could have been switched in 1985.

Natural gas was the primary replacement fuel for electricity. It could have replaced 7.4 billion kWh (0.025 quads) of purchased electricity. Residual and distillate fuel oils were the next most likely alternative fuels for purchased electricity, potentially replacing 4.1 (0.014 quads) and 2.9 billion kWh (0.010 quads), respectively.

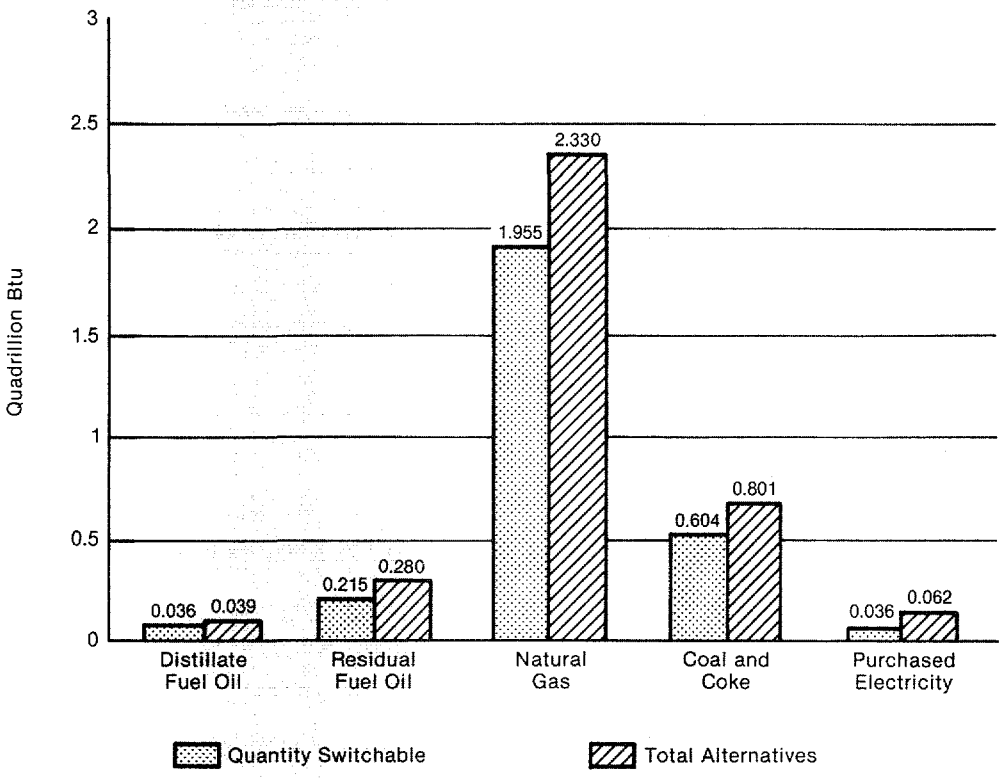
There was little flexibility in choice of fuels for the distillate fuel oil that was switchable. The amount of distillate fuel oil that was switchable was 6.2 million barrels (0.036 quads), and the sum of the alternatives was 6.7 million barrels (0.039 quads). This small difference indicates that distillate was among the most inflexible sources of heat and power with respect to the number of viable alternatives.

This lack of flexibility is borne out by the fact that one replacement fuel, natural gas, totally dominates the others. Natural gas could have replaced 4.2 million barrels (0.024 quads), 67 percent of switchable distillate consumption. Residual fuel oil was the next highest replacement fuel, accounting for 1.3 million barrels (0.008 quads) or 21 percent of switchable consumption.

Switchable natural gas consumption was also relatively inflexible. A total of 1.9 Tcf (2.0 quads) was switchable, and the sum of the alternatives was 2.3 Tcf (2.4 quads). The principal alternatives were distillate and residual fuel oils, either of which could have replaced 0.8 Tcf (0.8 quads) of natural gas. The only other significant alternative for natural gas was LPG, which could have replaced 0.5 Tcf (0.5 quads).

Residual fuel oil was reasonably flexible in terms of its alternatives. The total switchable consumption was 34.2 million barrels (0.21 quads), which was substantially exceeded by the sum of consumption of the potential alternatives, 44.5 million barrels (0.28 quads). Natural gas was the primary alternative fuel for residual fuel oil. It was capable of replacing 24.9 million barrels (0.16 quads), or 73 percent of the total switchable consumption of residual fuel oil. The second and third

Figure 4. Quantity of Switchable Energy and Total Alternative Energy in the Manufacturing Sector for 1985



Source: Energy Information Administration, Form EIA 846(S), "1985 Manufacturing Energy Consumption Survey".

most prevalent alternatives were distillate fuel oil and LPG. These petroleum-based fuels could have replaced 10.6 and 5.0 million barrels (0.07 and 0.03 quads), respectively. While no single alternative fuel could have replaced all the switchable residual fuel oil, most of the replacement could have been accomplished through the use of distillate fuel oil, LPG and natural gas.

Finally, the MECS data indicate some flexibility in the replacement of coal and coke. The total switchable consumption of coal and coke was 24.9 million short tons (0.55 quads). The sum of the alternatives for coal and coke was 33.0 million short tons (0.73 quads), one-third greater than the switchable consumption. The primary alternative fuel was natural gas, which could have replaced 16.8 million short tons (0.37 quads). Residual fuel oil was second, capable of replacing 8.9 million short tons (0.20 quads), and distillate was third, potentially replacing 5.8 million short tons (0.13 quads).

Detailed Statistics Tables

Table 1. Nonswitchable Minimum Requirements and Maximum Consumption Potential by Census Region, 1985
(Physical Units)

Type of Energy	Actual Consumption	Minimum Consumption[a]	Maximum Consumption[b]	
			Low Estimate	High Estimate
Total United States				
Purchased Electricity (million kWh)[c]	643,362	632,733	660,714	662,344
Natural Gas (billion cubic feet)	4,512	2,618	5,055	5,071
Distillate Fuel Oil (thousand barrels)	31,684	25,449	203,443	210,046
Residual Fuel Oil (thousand barrels)	80,252	46,096	243,774	250,892
Coal and Coke (thousand short tons)	83,003	58,095	85,183	85,337
Northeast Census Region				
Purchased Electricity (million kWh)[c]	92,378	91,287	93,705	94,085
Natural Gas (billion cubic feet)	467	235	526	529
Distillate Fuel Oil (thousand barrels)	10,634	8,491	34,137	34,957
Residual Fuel Oil (thousand barrels)	32,910	21,670	56,918	57,711
Coal and Coke (thousand short tons)	10,278	8,186	10,460	10,490
Midwest Census Region				
Purchased Electricity (million kWh)[c]	184,636	182,366	189,470	189,567
Natural Gas (billion cubic feet)	1,265	702	1,470	1,474
Distillate Fuel Oil (thousand barrels)	5,792	4,867	56,295	58,266
Residual Fuel Oil (thousand barrels)	12,696	4,282	53,750	55,554
Coal and Coke (thousand short tons)	37,826	28,740	38,871	38,913
South Census Region				
Purchased Electricity (million kWh)[c]	259,788	254,347	269,087	270,042
Natural Gas (billion cubic feet)	2,285	1,443	2,477	2,484
Distillate Fuel Oil (thousand barrels)	10,512	7,986	83,655	86,125
Residual Fuel Oil (thousand barrels)	24,036	15,333	101,236	105,282
Coal and Coke (thousand short tons)	28,598	17,852	29,315	29,385
West Census Region				
Purchased Electricity (million kWh)[c]	106,560	104,733	108,452	108,649
Natural Gas (billion cubic feet)	495	238	582	584
Distillate Fuel Oil (thousand barrels)	4,746	4,106	29,357	30,698
Residual Fuel Oil (thousand barrels)	10,611	4,811	31,869	32,344
Coal and Coke (thousand short tons)	6,300	3,317	6,537	6,550

[a] Minimum consumption represents actual 1985 consumption decreased by the quantity of the designated type of energy that would no longer have been required if all ascertained switching from that type of energy had occurred. The minimum value includes the quantity of 1985 consumption for which switching capability was not ascertained.

[b] Maximum consumption represents actual 1985 consumption increased by the quantity of the designated type of energy that would have been required if all ascertained switching to that type of energy had occurred. The low estimate assumes that when the designated type of energy was reported as an alternative to two or more types of energy at an establishment, only a single substitution was possible at any one time. The substitutable amount consists of the single largest switchable amount from any type of energy to the designated type of energy. The high estimate assumes that all indicated substitutions were simultaneously possible and the substitutable amount consists of the sum of all possible switches to the designated type of energy. Both estimates assume that 1985 output remained constant.

[c] "Purchased Electricity" represents those quantities for which payment was made, and which were available onsite for consumption. The estimated values specifically exclude electricity generated onsite, transferred in from another establishment of the same company (including company-owned electricity generation facilities), quantities purchased and paid for by a central purchasing entity, and quantities for which payment was made in kind. In addition, "Purchased Electricity" has not been adjusted to account for any quantities that might have been resold or transferred out.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846(S), "1985 Manufacturing Energy Consumption Survey: Part II--Fuel-Switching Capability."

Table 2. Capability to Switch From Designated Types of Energy by Census Region and Minimum Leadtime to Switch, 1985
(Physical Units)

Type of Energy and Minimum Leadtime to Switch[b]	Quantity Switchable[a]				
	Total United States	Census Region			
		Northeast	Midwest	South	West
Purchased Electricity(million kilowatthours)[c]					
Less than one day	6,247	691	1,489	3,258	808
One day through one week	2,676	244	344	1,325	763
More than one week but within 30 days	1,662	132	432	842	257
Leadtime not ascertainable	46	24	4	16	Q
Total	10,631	1,090	2,270	5,442	1,829
Natural Gas (billion cubic feet)					
Less than one day	862	121	243	389	108
One day through one week	577	62	164	263	87
More than one week but within 30 days	378	38	135	160	45
Leadtime not ascertainable	79	10	20	32	17
Total	1,895	232	563	843	257
Distillate Fuel Oil (thousand barrels)					
Less than one day	2,695	905	375	956	458
One day through one week	2,000	333	221	Q	176
More than one week but within 30 days	1,522	900	325	291	6
Leadtime not ascertainable	20	Q	Q	Q	1
Total	6,236	2,143	925	2,528	640
Residual Fuel Oil (thousand barrels)					
Less than one day	14,802	5,285	2,297	4,342	2,877
One day through one week	12,544	3,035	4,950	2,748	1,811
More than one week but within 30 days	6,497	2,887	W	W	1,111
Leadtime not ascertainable	313	33	W	W	1
Total	34,156	11,240	8,414	8,703	5,800
Coal and Coke (thousand short tons)					
Less than one day	13,351	1,278	5,099	5,114	1,860
One day through one week	7,406	429	2,619	3,725	633
More than one week but within 30 days	3,807	329	1,268	1,726	484
Leadtime not ascertainable	343	56	100	181	6
Total	24,907	2,092	9,087	10,746	2,983

[a] A specific type of energy may be switchable if the combustors had the necessary machinery or equipment in place so that the substitution could have been introduced within 30 days, while holding output constant, and without extensive modifications to the combustor. See Appendix A for more details. The estimates of quantities switchable represent the *total* consumption during 1985 that could have been replaced by an alternative fuel within the standard leadtime. These amounts can also be interpreted as the amount of 1985 consumption that could have been avoided if all possible switching within the leadtime had taken place.

[b] "Time to switch" represents the minimum lead time required to convert to a primary replacement type of energy in place of the indicated type of energy. If two or more replacement fuels were equally substitutable, respondents were instructed to indicate the minimum leadtime for the substitution that could have been made in the shortest time. (See questionnaire and instructions in Appendix C.)

[c] "Purchased Electricity" represents those quantities for which payment was made, and which were available onsite for consumption. The estimated values specifically exclude electricity generated onsite, transferred in from another establishment of the same company (including company-owned electricity generation facilities), quantities purchased and paid for by a central purchasing entity, and quantities for which payment was made in kind. In addition, "Purchased Electricity" has not been adjusted to account for any quantities that might have been resold or transferred out.

W=Withheld to avoid disclosing data for individual companies. Data are included in higher level totals.

Q=Withheld because relative standard error is greater than or equal to 50 percent. Data are included in higher level totals.

Note: Totals may not equal sum of components because of independent rounding.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846(F), "1985 Manufacturing Energy Consumption Survey: Part II--Fuel-Switching Capability."

Table 3. Capability to Substitute Alternative Types of Energy for Purchased Electricity, 1985

(Million Kilowatthours)

Selected Characteristics		Purchased Electricity			Alternative Types of Energy[a]					
		Total Purchased[b]	Switchable	Not Switchable	Natural Gas	Distillate Fuel Oil	Residual Fuel Oil	Coal and Coke	LPG	Other[c]
SIC Code[d] and Industries										
20	Food and Kindred Products	45,053	1,004	37,545	616	404	179	92	Q	Q
21	Tobacco Manufactures	1,389	W	1,301	Q	W	0	0	0	0
22	Textile Mill Products	25,416	20	22,106	W	Q	Q	W	0	Q
23	Apparel and Other Textile Products	4,026	Q	2,868	0	Q	0	0	0	0
24	Lumber and Wood Products	14,039	213	10,835	Q	Q	W	0	Q	95
25	Furniture and Fixtures	4,243	Q	3,297	Q	0	0	0	0	Q
26	Paper and Allied Products	53,302	1,824	44,196	1,291	710	983	255	Q	148
2621	*Paper Mills, Except Building Paper*	28,813	1,211	23,309	914	W	575	115	0	148
2631	*Paperboard Mills*	10,390	414	9,115	317	117	297	89	0	0
27	Printing and Publishing	11,182	175	8,383	70	46	Q	0	Q	0
28	Chemicals and Allied Products	124,698	1,242	114,094	817	347	492	W	67	W
2819	*Industrial Inorganic Chemicals*	33,438	210	31,675	107	38	63	102	0	*
2821	*Plastics Materials and Resins*	11,805	40	10,803	W	8	14	0	0	0
2869	*Industrial Organic Chemicals*	19,927	146	19,046	94	3	W	0	W	W
2873	*Nitrogenous Fertilizers*	3,714	45	3,213	W	W	0	0	0	0
29	Petroleum and Coal Products	35,516	2,647	30,451	2,047	784	705	34	1,276	754
2911	*Petroleum Refining*	33,912	2,625	29,231	2,032	762	690	W	1,261	754
30	Rubber and Misc. Plastics Products	25,757	133	20,233	Q	25	Q	0	Q	Q
31	Leather and Leather Products	1,053	8	827	W	0	0	Q	0	0
32	Stone, Clay and Glass Products	30,700	165	25,563	Q	40	0	0	5	Q
3241	*Cement, Hydraulic*	9,926	1	8,143	1	0	0	0	0	0
33	Primary Metal Industries	136,081	1,938	125,854	1,854	116	1,438	1	Q	W
3312	*Blast Furnaces and Steel Mills*	37,711	1,783	34,280	1,738	W	1,438	0	0	W
3334	*Primary Aluminum*	58,846	W	58,548	W	W	0	0	0	0
34	Fabricated Metal Products	26,694	248	20,983	82	61	4	W	Q	Q
35	Machinery, Except Electrical	28,942	332	21,507	39	47	105	0	Q	Q
36	Electric and Electronic Equipment	30,683	283	23,285	126	170	Q	1	Q	0
37	Transportation Equipment	33,669	308	28,524	209	117	W	W	W	0
38	Instruments and Related Products	7,732	65	6,439	Q	Q	58	W	0	0
39	Misc. Manufacturing Industries	3,188	Q	2,594	Q	Q	Q	0	0	0
	Total	643,362	10,631	550,886	7,437	2,937	4,149	626	1,654	1,358
Census Region										
Northeast		92,378	1,090	74,551	611	184	836	51	119	100
Midwest		184,636	2,270	160,546	1,552	662	1,064	139	229	140
South		259,788	5,442	224,958	3,784	1,431	1,423	375	1,049	883
West		106,560	1,829	90,831	1,490	661	824	62	256	234
Total		643,362	10,631	550,886	7,437	2,937	4,149	626	1,654	1,358
Value of Shipments[e] (million dollars)										
Under 20		120,086	1,145	91,975	564	284	161	40	288	Q
20-49		102,416	1,203	83,773	693	379	354	W	Q	267
50-99		82,745	588	70,154	386	299	214	W	W	7
100-249		140,835	1,750	127,489	1,304	912	734	220	52	112
250-499		86,092	1,059	80,383	648	103	436	75	92	W
500 and Over		111,189	4,885	97,112	3,843	960	2,248	251	1,186	303
Total		643,362	10,631	550,886	7,437	2,937	4,149	626	1,654	1,358
Employment Size[e]										
Under 50		45,084	463	32,801	201	Q	34	Q	Q	Q
50-99		40,347	398	31,860	287	69	93	Q	Q	Q
100-249		109,025	1,552	90,032	958	561	403	58	213	265
250-499		110,296	1,239	96,466	941	292	562	52	224	224
500-999		138,949	2,256	122,040	1,822	929	926	131	422	291
1,000 and Over		199,661	4,723	177,688	3,227	931	2,130	351	600	W
Total		643,362	10,631	550,886	7,437	2,937	4,149	626	1,654	1,358

[a] "Alternative types of energy" consist of those that could have been substituted for purchased electricity during 1985. The quantities are expressed in millions of kilowatthours, and therefore represent the quantity of purchased electricity that could have been displaced by the given alternate type of energy.

[b] The estimates of total purchased electricity represent the quantities that were available for use onsite during 1985. The estimates include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

[c] "Other" includes all other types of energy that respondents indicated could have been consumed in place of purchased electricity.

[d] See Appendices A and D for descriptions of the Standard Industrial Classification system.

[e] Value of Shipments and Employment Size were supplied by the Bureau of the Census. See Appendix A.

*=*Estimate less than 0.5 rounded to zero.*

W=Withheld to avoid disclosing data for individual companies. Data are included in higher level totals.

Q=Withheld because relative standard error is greater than or equal to 50 percent. Data are included in higher level totals.

Note: Totals may not equal sum of components because of independent rounding.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846(S), "1985 Manufacturing Energy Consumption Survey: Part II--Fuel-Switching Capability."

Table 4. Capability to Substitute Alternative Types of Energy for Natural Gas, 1985
(Billion Cubic Feet)

Selected Characteristics	Natural Gas			Alternative Types of Energy[a]					
	Total Consumed[b]	Switchable	Not Switchable	Purchased Electricity	Distillate Fuel Oil	Residual Fuel Oil	Coal and Coke	LPG	Other[c]
SIC Code[d] and Industries									
20 Food and Kindred Products	462	279	132	2	131	144	8	40	3
21 Tobacco Manufactures	3	2	1	0	1	1	0	*	Q
22 Textile Mill Products	89	60	16	Q	16	33	1	14	0
23 Apparel and Other Textile Products	11	4	3	Q	2	1	*	1	Q
24 Lumber and Wood Products	24	8	9	0	4	1	0	3	Q
25 Furniture and Fixtures	18	6	9	Q	2	1	Q	3	Q
26 Paper and Allied Products	387	238	111	11	88	161	6	10	6
2621 Paper Mills, Except Building Paper	152	90	41	6	31	63	3	2	*
2631 Paperboard Mills	124	82	34	4	25	64	1	2	5
27 Printing and Publishing	31	10	14	1	5	2	0	3	*
28 Chemicals and Allied Products	1,153	328	787	8	155	161	4	53	7
2819 Industrial Inorganic Chemicals	118	39	74	*	18	23	1	3	Q
2821 Plastics Materials and Resins	W	44	76	Q	21	12	*	W	W
2869 Industrial Organic Chemicals	389	91	291	W	41	44	1	28	1
2873 Nitrogenous Fertilizers	190	11	176	0	11	1	0	*	*
29 Petroleum and Coal Products	694	297	371	8	118	121	2	164	22
2911 Petroleum Refining	668	284	362	8	108	119	1	163	22
30 Rubber and Misc. Plastics Products	94	57	25	*	34	29	*	6	Q
31 Leather and Leather Products	4	2	2	Q	1	1	0	Q	0
32 Stone, Clay and Glass Products	372	177	148	1	96	28	6	60	Q
3241 Cement, Hydraulic	16	6	6	0	2	1	3	*	0
33 Primary Metal Industries	666	247	377	5	80	105	7	69	2
3312 Blast Furnaces and Steel Mills	400	139	249	W	32	94	6	14	W
3334 Primary Aluminum	W	14	7	0	4	2	0	8	1
34 Fabricated Metal Products	169	52	85	2	22	11	1	21	1
35 Machinery, Except Electrical	101	32	46	1	13	6	1	14	*
36 Electric and Electronic Equipment	80	27	34	1	12	5	*	10	*
37 Transportation Equipment	121	54	54	1	23	13	2	17	1
38 Instruments and Related Products	20	10	7	Q	6	4	0	2	0
39 Misc. Manufacturing Industries	14	4	7	0	2	1	*	1	Q
Total	4,512	1,895	2,238	42	810	830	38	493	45
Census Region									
Northeast	467	232	169	1	90	118	2	43	3
Midwest	1,265	563	581	14	238	226	20	148	10
South	2,285	843	1,304	22	372	369	12	234	18
West	495	257	183	5	110	118	4	68	15
Total	4,512	1,895	2,238	42	810	830	38	493	45
Value of Shipments[e] (million dollars)									
Under 20	649	225	305	5	119	56	6	58	5
20-49	585	270	237	6	134	100	4	62	2
50-99	548	279	197	2	158	97	5	61	2
100-249	898	416	423	15	163	212	7	76	7
250-499	619	256	341	3	93	145	6	36	7
500 and Over	1,212	449	735	12	142	220	10	199	23
Total	4,512	1,895	2,238	42	810	830	38	493	45
Employment Size[e]									
Under 50	248	71	133	2	41	21	Q	15	Q
50-99	311	125	147	2	74	41	3	28	3
100-249	752	320	331	4	165	121	8	60	2
250-499	839	368	406	6	167	167	8	84	2
500-999	878	425	383	17	179	183	3	133	25
1,000 and Over	1,484	586	838	11	184	298	15	172	11
Total	4,512	1,895	2,238	42	810	830	38	493	45

[a] "Alternative types of energy" consist of those that could have been substituted for natural gas during 1985. The quantities are expressed in billion cubic feet, and, therefore, represent the quantity of natural gas that could have been displaced by the given alternate type of energy.

[b] The estimates of total consumption include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

[c] "Other" includes all other types of energy that respondents indicated could have been consumed in place of natural gas.

[d] See Appendices A and D for descriptions of the Standard Industrial Classification system.

[e] Value of Shipments and Employment Size were supplied by the Bureau of the Census. See Appendix A.

*=Estimate less than 0.5 rounded to zero.

W=Withheld to avoid disclosing data for individual companies. Data are included in higher level totals.

Q=Withheld because relative standard error is greater than or equal to 50 percent. Data are included in higher level totals.

Note: Totals may not equal sum of components because of independent rounding.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846(S), "1985 Manufacturing Energy Consumption Survey: Part II--Fuel-Switching Capability."

Table 5. Capability to Substitute Alternative Types of Energy for Distillate Fuel Oil, 1985

(Thousand Barrels)

Selected Characteristics		Distillate Fuel Oil			Alternative Types of Energy[a]					
		Total Consumed[b]	Switchable	Not Switchable	Purchased Electricity	Natural Gas	Residual Fuel Oil	Coal and Coke	LPG	Other[c]
SIC Code[d] and Industries										
20	Food and Kindred Products	4,215	1,897	1,929	Q	883	301	Q	Q	0
21	Tobacco Manufactures	55	Q	W	0	Q	1	0	1	*
22	Textile Mill Products	922	421	301	Q	Q	76	Q	15	*
23	Apparel and Other Textile Products	373	Q	192	0	Q	Q	0	0	0
24	Lumber and Wood Products	3,911	156	2,841	Q	26	W	0	Q	Q
25	Furniture and Fixtures	342	52	196	Q	Q	Q	Q	Q	Q
26	Paper and Allied Products	1,963	331	1,035	Q	280	41	29	18	W
2621	*Paper Mills, Except Building Paper*	1,030	168	534	0	128	15	23	W	W
2631	*Paperboard Mills*	197	27	142	*	22	2	3	3	0
27	Printing and Publishing	256	43	163	Q	43	Q	0	Q	0
28	Chemicals and Allied Products	2,741	694	1,663	1	631	32	W	Q	2
2819	*Industrial Inorganic Chemicals*	515	132	313	0	130	2	0	2	Q
2821	*Plastics Materials and Resins*	384	214	74	*	213	*	W	0	W
2869	*Industrial Organic Chemicals*	755	109	571	0	56	6	1	Q	*
2873	*Nitrogenous Fertilizers*	25	15	9	0	15	W	0	0	0
29	Petroleum and Coal Products	2,807	967	1,462	Q	653	527	Q	224	W
2911	*Petroleum Refining*	752	263	449	1	W	W	1	167	W
30	Rubber and Misc. Plastics Products	W	194	241	Q	115	81	0	8	0
31	Leather and Leather Products	199	Q	Q	0	Q	Q	Q	Q	0
32	Stone, Clay and Glass Products	5,643	453	3,621	Q	392	45	2	48	Q
3241	*Cement, Hydraulic*	643	56	496	W	37	18	0	W	0
33	Primary Metal Industries	2,098	171	1,514	Q	141	W	W	Q	Q
3312	*Blast Furnaces and Steel Mills*	942	42	873	0	38	W	0	W	0
3334	*Primary Aluminum*	52	W	42	0	W	0	0	1	0
34	Fabricated Metal Products	1,721	217	1,155	Q	162	Q	0	Q	Q
35	Machinery, Except Electrical	1,298	158	696	40	86	14	Q	Q	0
36	Electric and Electronic Equipment	W	115	259	Q	83	23	W	Q	Q
37	Transportation Equipment	1,501	211	1,175	50	136	W	W	10	Q
38	Instruments and Related Products	W	36	118	Q	34	Q	0	0	0
39	Misc. Manufacturing Industries	164	24	96	0	14	Q	0	0	0
	Total	31,684	6,236	18,844	344	4,165	1,300	178	Q	59
Census Region										
Northeast		10,634	2,143	6,359	106	1,532	722	47	190	Q
Midwest		5,792	925	4,089	Q	646	141	Q	237	Q
South		10,512	2,528	5,339	29	1,409	290	Q	Q	14
West		4,746	640	3,058	2	578	146	21	161	1
Total		31,684	6,236	18,844	344	4,165	1,300	178	Q	59
Value of Shipments[e] (million dollars)										
Under 20		17,052	3,335	9,475	Q	2,001	714	Q	Q	Q
20-49		5,353	976	3,401	30	714	267	6	174	16
50-99		2,463	590	1,480	9	452	115	21	61	*
100-249		W	549	1,479	34	357	141	24	60	1
250-499		W	391	1,128	5	364	31	18	16	W
500 and Over		W	395	1,881	W	277	33	W	172	W
Total		31,684	6,236	18,844	344	4,165	1,300	178	Q	59
Employment Size[e]										
Under 50		9,279	2,117	5,210	Q	1,005	497	Q	Q	Q
50-99		4,631	735	2,838	Q	569	127	1	142	Q
100-249		6,465	1,109	3,691	Q	773	370	12	40	Q
250-499		3,797	934	2,323	31	829	113	6	76	Q
500-999		2,793	737	1,422	20	531	125	28	238	10
1,000 and Over		4,720	605	3,360	67	459	67	47	70	2
Total		31,684	6,236	18,844	344	4,165	1,300	178	Q	59

[a] "Alternative types of energy" consist of those that could have been substituted for distillate fuel oil during 1985. The quantities are expressed in thousands of barrels, and, therefore, represent the quantity of distillate fuel oil that could have been displaced by the given alternate type of energy.

[b] The estimates of total consumption include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

[c] "Other" includes all other types of energy that respondents indicated could have been consumed in place of distillate fuel oil.

[d] See Appendices A and D for descriptions of the Standard Industrial Classification system.

[e] Value of Shipments and Employment Size were supplied by the Bureau of the Census. See Appendix A.

*=Estimate less than 0.5 rounded to zero.

W=Withheld to avoid disclosing data for individual companies. Data are included in higher level totals.

Q=Withheld because relative standard error is greater than or equal to 50 percent. Data are included in higher level totals.

Note: Totals may not equal sum of components because of independent rounding.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846(S), "1985 Manufacturing Energy Consumption Survey: Part II--Fuel-Switching Capability."

Table 6. Capability to Substitute Alternative Types of Energy for Residual Fuel Oil, 1985

(Thousand Barrels)

Selected Characteristics	Residual Fuel Oil			Alternative Types of Energy[a]					
	Total Consumed[b]	Switchable	Not Switchable	Purchased Electricity	Natural Gas	Distillate Fuel Oil	Coal and Coke	LPG	Other[c]
SIC Code[d] and Industries									
20 Food and Kindred Products	6,290	2,883	2,694	W	2,485	850	66	95	0
21 Tobacco Manufactures	308	107	176	0	107	0	0	Q	Q
22 Textile Mill Products	2,858	1,125	1,176	Q	903	275	86	Q	Q
23 Apparel and Other Textile Products	165	36	Q	0	Q	29	0	0	0
24 Lumber and Wood Products	W	138	132	0	79	107	0	0	0
25 Furniture and Fixtures	145	38	73	0	14	24	0	0	0
26 Paper and Allied Products	W	7,000	15,684	219	4,377	2,565	423	150	366
2621 Paper Mills, Except Building Paper	12,567	3,694	7,710	W	1,967	1,945	92	W	298
2631 Paperboard Mills	6,697	1,944	4,435	23	1,508	463	8	Q	0
27 Printing and Publishing	W	Q	48	0	Q	Q	0	Q	0
28 Chemicals and Allied Products	11,477	4,634	5,413	74	3,258	1,581	191	W	64
2819 Industrial Inorganic Chemicals	1,220	523	543	36	306	166	129	0	0
2821 Plastics Materials and Resins	1,059	323	472	0	279	90	0	W	W
2869 Industrial Organic Chemicals	W	854	554	0	770	214	W	0	W
2873 Nitrogenous Fertilizers	W	W	0	0	W	W	0	0	0
29 Petroleum and Coal Products	17,079	10,473	5,299	383	8,352	2,423	W	4,438	945
2911 Petroleum Refining	15,731	10,017	4,789	383	8,330	1,990	W	4,438	945
30 Rubber and Misc. Plastics Products	1,729	905	556	0	543	488	W	Q	0
31 Leather and Leather Products	378	33	220	0	31	W	0	0	0
32 Stone, Clay and Glass Products	1,491	1,199	66	0	704	707	104	W	0
3241 Cement, Hydraulic	W	148	W	0	103	44	W	0	0
33 Primary Metal Industries	6,405	2,974	3,382	W	2,380	374	W	W	W
3312 Blast Furnaces and Steel Mills	5,458	2,776	2,682	W	2,292	W	W	W	W
3334 Primary Aluminum	W	W	0	0	W	W	0	0	0
34 Fabricated Metal Products	801	351	398	W	270	96	W	13	0
35 Machinery, Except Electrical	1,152	557	388	Q	334	365	W	Q	0
36 Electric and Electronic Equipment	984	389	407	Q	256	159	W	W	0
37 Transportation Equipment	2,630	771	1,530	89	543	223	W	W	W
38 Instruments and Related Products	W	422	633	0	212	251	0	0	0
39 Misc. Manufacturing Industries	312	106	150	Q	68	62	0	0	0
Total	80,252	34,156	38,467	1,035	24,937	10,592	1,365	5,009	1,563
Census Region									
Northeast	32,910	11,240	17,609	406	5,985	5,173	343	1,049	971
Midwest	12,696	8,414	3,149	13	7,391	1,312	361	2,096	164
South	24,036	8,703	13,646	298	6,563	2,276	530	563	305
West	10,611	5,800	4,063	317	4,999	1,831	131	1,301	123
Total	80,252	34,156	38,467	1,035	24,937	10,592	1,365	5,009	1,563
Value of Shipments[e] (million dollars)									
Under 20	7,992	2,699	3,585	Q	1,753	1,250	98	Q	Q
20-49	10,063	3,859	4,814	92	2,076	2,065	170	80	130
50-99	11,984	4,493	6,142	126	2,781	1,991	90	211	18
100-249	16,280	6,437	8,605	144	5,157	1,601	567	169	289
250-499	10,994	4,279	5,964	W	2,820	1,553	380	582	W
500 and Over	22,940	12,388	9,357	567	10,350	2,131	60	3,887	966
Total	80,252	34,156	38,467	1,035	24,937	10,592	1,365	5,009	1,563
Employment Size[e]									
Under 50	2,845	701	1,427	W	160	507	0	0	Q
50-99	3,420	1,693	1,020	W	1,255	718	Q	44	51
100-249	13,021	5,468	5,735	169	3,337	2,833	301	811	*
250-499	13,254	5,140	6,757	154	3,997	1,819	90	940	120
500-999	16,532	7,128	7,717	170	4,990	2,159	391	712	1,240
1,000 and Over	31,180	14,026	15,812	422	11,198	2,556	580	2,502	149
Total	80,252	34,156	38,467	1,035	24,937	10,592	1,365	5,009	1,563

[a] "Alternative types of energy" consist of those that could have been substituted for residual fuel oil during 1985. The quantities are expressed in thousands of barrels, and, therefore, represent the quantity of residual fuel oil that could have been displaced by the given alternate type of energy.

[b] The estimates of total consumption include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

[c] "Other" includes all other types of energy that respondents indicated could have been consumed in place of residual fuel oil.

[d] See Appendices A and D for descriptions of the Standard Industrial Classification system.

[e] Value of Shipments and Employment Size were supplied by the Bureau of the Census. See Appendix A.

*=Estimate less than 0.5 rounded to zero.

W=Withheld to avoid disclosing data for individual companies. Data are included in higher level totals.

Q=Withheld because relative standard error is greater than or equal to 50 percent. Data are included in higher level totals.

Note: Totals may not equal sum of components because of independent rounding.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846(S), "1985 Manufacturing Energy Consumption Survey: Part II--Fuel-Switching Capability."

Table 7. Capability to Substitute Alternative Types of Energy for Coal and Coke, 1985

(Thousand Short Tons)

Selected Characteristics		Coal and Coke			Alternative Types of Energy[a]					
		Total Consumed[b]	Switchable	Not Switchable	Purchased Electricity	Natural Gas	Distillate Fuel Oil	Residual Fuel Oil	LPG	Other[c]
SIC Code[d] and Industries										
20	Food and Kindred Products	5,693	2,895	2,507	W	2,505	1,084	652	0	23
21	Tobacco Manufactures	407	175	W	0	W	W	W	0	0
22	Textile Mill Products	1,631	782	637	0	588	139	459	W	W
23	Apparel and Other Textile Products	70	9	48	0	7	9	0	0	0
24	Lumber and Wood Products	W	0	0	0	0	0	0	0	0
25	Furniture and Fixtures	89	17	54	0	0	0	W	W	5
26	Paper and Allied Products	14,015	6,563	6,355	231	2,786	1,860	3,316	19	406
2621	*Paper Mills, Except Building Paper*	8,315	3,391	4,143	199	1,359	884	1,839	0	158
2631	*Paperboard Mills*	4,626	2,430	1,929	32	1,325	373	1,334	8	248
27	Printing and Publishing	W	0	12	0	0	0	0	0	0
28	Chemicals and Allied Products	14,449	5,100	8,240	W	3,044	1,175	1,788	W	0
2819	*Industrial Inorganic Chemicals*	1,882	363	796	130	165	67	101	0	0
2821	*Plastics Materials and Resins*	1,276	678	530	0	462	198	W	W	0
2869	*Industrial Organic Chemicals*	W	1,477	2,550	W	1,337	331	W	W	0
2873	*Nitrogenous Fertilizers*	0	0	0	0	0	0	0	0	0
29	Petroleum and Coal Products	339	266	73	Q	109	179	190	55	0
2911	*Petroleum Refining*	336	263	73	0	106	175	187	W	0
30	Rubber and Misc. Plastics Products	W	129	88	0	16	W	W	0	0
31	Leather and Leather Products	32	Q	18	Q	0	Q	0	0	Q
32	Stone, Clay and Glass Products	14,694	5,523	6,955	Q	5,069	806	1,382	145	Q
3241	*Cement, Hydraulic*	W	4,597	5,076	0	4,184	571	1,126	0	Q
33	Primary Metal Industries	26,950	2,151	24,270	1	1,934	208	W	32	0
3312	*Blast Furnaces and Steel Mills*	24,039	1,931	22,080	0	1,715	W	W	W	0
3334	*Primary Aluminum*	0	0	0	0	0	0	0	0	0
34	Fabricated Metal Products	361	43	282	Q	32	W	W	W	0
35	Machinery, Except Electrical	765	323	382	0	283	118	50	W	0
36	Electric and Electronic Equipment	W	55	292	0	55	18	W	1	0
37	Transportation Equipment	1,892	425	1,270	W	354	84	W	W	0
38	Instruments and Related Products	W	W	W	W	0	0	W	0	0
39	Misc. Manufacturing Industries	48	W	Q	0	W	W	0	0	0
	Total	83,003	24,907	52,076	568	16,835	5,762	8,894	542	439
Census Region										
Northeast		10,278	2,092	7,032	57	715	703	1,254	W	0
Midwest		37,826	9,087	27,174	W	7,269	2,272	1,467	W	146
South		26,598	10,746	15,943	444	6,483	1,707	5,637	399	89
West		6,300	2,983	1,927	W	2,368	1,081	535	0	203
Total		83,003	24,907	52,076	568	16,835	5,762	8,894	542	439
Value of Shipments[e] (million dollars)										
Under 20		W	1,965	3,289	Q	1,720	534	641	140	Q
20-49		10,150	3,767	4,855	4	2,973	989	857	W	73
50-99		8,812	3,457	4,476	65	2,353	771	1,140	39	W
100-249		W	7,178	7,170	W	3,999	1,637	3,069	W	263
250-499		W	3,697	10,212	W	2,367	1,056	1,773	51	W
500 and Over		27,102	4,843	22,074	300	3,423	776	1,413	W	0
Total		83,003	24,907	52,076	568	16,835	5,762	8,894	542	439
Employment Size[e]										
Under 50		1,206	242	232	Q	242	Q	Q	Q	0
50-99		2,681	857	1,588	0	692	208	169	Q	Q
100-249		13,892	5,340	6,888	W	4,059	1,462	1,504	W	Q
250-499		9,268	4,403	3,624	W	3,336	1,009	1,203	W	88
500-999		10,820	4,378	5,441	87	2,317	1,157	1,705	28	191
1,000 and Over		45,136	9,688	34,304	427	6,189	1,856	4,239	242	148
Total		83,003	24,907	52,076	568	16,835	5,762	8,894	542	439

[a] "Alternative types of energy" consist of those that could have been substituted for coal and coke during 1985. The quantities are expressed in thousand short tons, and, therefore, represent the quantity of coal and coke that could have been displaced by the given alternate type of energy.

[b] The estimates of total consumption include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

[c] "Other" includes all other types of energy that respondents indicated could have been consumed in place of coal and coke.

[d] See Appendices A and D for descriptions of the Standard Industrial Classification system.

[e] Value of Shipments and Employment Size were supplied by the Bureau of the Census. See Appendix A.

W=Withheld to avoid disclosing data for individual companies. Data are included in higher level totals.

Q=Withheld because relative standard error is greater than or equal to 50 percent. Data are included in higher level totals.

Note: Totals may not equal sum of components because of independent rounding.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846(S), "1985 Manufacturing Energy Consumption Survey: Part II--Fuel-Switching Capability."

Appendix A

Survey Design, Implementation and Estimates

Appendix A

Survey Design, Implementation and Estimates

Introduction

The 1985 Manufacturing Energy Consumption Survey (MECS) has been designed by the Energy Information Administration (EIA) to provide information related to energy consumption in the manufacturing sector. The MECS data collection consisted of two parts. Part I collected data on energy consumption and related matters. The estimates from Part I of the survey are presented in a separate EIA report.[3] Part II collected information on the capability of manufacturers to substitute alternate fuels for those actually consumed in 1985. The estimates from Part II are presented in the detailed statistics section of this report.

The basic unit of data collection for this survey was the manufacturing establishment. A nationally representative sample of these establishments supplied the information through mailed questionnaires. The questionnaires for Part I of the survey were mailed on July 14, 1986; those for Part II were mailed on November 26, 1986. The Industry Division of the Bureau of the Census selected the MECS sample according to EIA design specifications; conducted the fieldwork; and handled data processing, again with EIA input.

This appendix presents a summary of the design and implementation procedures for Part II of the survey, and describes the types of estimates included in this report. Complete details are available in a methodological report on the MECS published by EIA.[4]

Concept of Fuel-Switching Capability

One of the major problems in designing a fuel-switching data collection as part of the MECS survey was to define the concept of fuel switching that the survey would measure. After extensive consultation with potential data users and data providers, EIA developed a tightly-specified concept of fuel-switching capability based on the following set of principles:

1. Switching data would cover consumption of energy for heat, power, and onsite electricity generation only. Switching of energy consumed as feedstock or raw material inputs would not be considered.
2. Switching data would focus on capability (what could be done) rather than actual performance (what was, or is being done) or future possibilities (what might be possible).
3. Switching capability would be collected for a closed historical reference period, rather than the present, or some future reference period.
4. Switching capability would be collected for the one-year reference period used for MECS consumption data, to tie in with the consumption data and avoid seasonal bias.
5. The survey would measure short-term response capability; that is, actions that could have taken place within 30 days of a decision to switch.
6. Switching capability would reflect the total flexibility provided by an establishment's equipment configuration. Both multiple-fired equipment and redundant or backup equipment could contribute to capability.
7. The survey would measure in-place capability; that is, capability provided by equipment that was already installed, or was available at the establishment site for installation during the reference period. Major modifications to the design capabilities of equipment and major capital expenditures were not to be considered in assessing capability.
8. Switching capability would be valid only if, following the switch, from one type of energy to

[3]Energy Information Administration, *Manufacturing Energy Consumption Survey: Consumption of Energy, 1985*, DOE/EIA-0512(85) (Washington, DC, 1988).

[4]Energy Information Administration, *Manufacturing Energy Consumption Survey: Methodological Report*, DOE/EIA-0514 (Washington, DC, 1988).

another, the establishment would have been able to maintain its actual production schedule during the reference period.

9. Switching capability provided by an establishment's equipment configuration could be limited or negated by legal or practical constraints such as binding supply contracts, interruptible service, environmental regulations, or unavailability of supply or delivery systems for a potential alternative.
10. Economic considerations were not to be considered a practical constraint in evaluating switching capability. The survey was designed to measure potential response to changes in economics or supply patterns.

Part II of the MECS obtained fuel-switching data by asking respondents to determine the amounts of 1985 energy consumption of five major types of energy that could have been switched to one or more alternatives in accordance with the previously-listed principles. The five types of energy were purchased electricity, natural gas, distillate oil, residual oil, and coal and coke combined. Respondents were directed to provide the quantities of switchable consumption by subtracting the quantities that were not switchable from the quantities that were actually consumed during 1985. Such an approach is clear and saves burden on the respondent because it permits subtracting those quantities known to be nonswitchable because of any one of the various conditions discussed above, rather than adding up those quantities for which all aspects of the concept are satisfied. Once the total switchable quantities had been determined, the remaining task was to determine how much of each switchable quantity could have been replaced by specific alternatives. The questionnaire materials in Appendix C of this report include three hypothetical examples of consumption and fuel-switching scenarios, accompained by instructions on how to determine switching capability.

Description of the Manufacturing Sector

The manufacturing sector consists of all manufacturing establishments in the 50 States and the District of Columbia. The working definition of a manufacturing establishment is the definition stated in the Office of Management and Budget's Standard Industrial Classification (SIC) Manual.[5]

A manufacturing establishment is an economic unit "...at a single physical location that is engaged in the mechanical or chemical transformation of materials or substances into new products. These establishments are usually described as plants, factories, or mills and characteristically use power-driven machines and materials-handling equipment. Establishments engaged in assembling component parts of manufactured products are also considered manufacturing if the new product is neither a structure nor other fixed improvement. Also included is the blending of materials such as lubricating oil, plastics, resins, or liquors."

The SIC Manual contains a hierarchial classification system that groups establishments according to their primary economic activities. This system divides the manufacturing sector into 20 major industrial groups that are relatively homogeneous with respect to primary output. Each of these major industrial groups is assigned a two-digit code. The two-digit codes for the manufacturing division range from SIC 20, Food and Kindred Products, through SIC 39, Miscellaneous Manufacturing Industries. Each major group is subdivided into three-digit groups which are further divided into four-digit industries. For example, SIC 20 includes SIC 201, Meat Products, which, in turn, is subdivided into SIC 2011, Meat Packing Plants; SIC 2012, Sausages and Other Prepared Meat Products; SIC 2016, Poultry Dressing Plants; and SIC 2017, Poultry and Egg Processing.

The SIC category is the single most important classification variable in the MECS data system, both for selecting the MECS sample and analyzing the MECS data. The categories of primary interest for the MECS are the 20 major industrial groups (SIC 20 through 39) and the 10 four-digit industries within these industry groups that consume the largest quantities of energy. A description of these 20 major industrial groups and 10 industries appears in Appendix D.

The Sampling Frame and Its Relationship to the Manufacturing Sector

As mentioned in the Introduction to this appendix, the Census Bureau serves as the collecting and compiling agent for the MECS. A major benefit of selecting the Census Bureau to provide this service was that the EIA was able to have access to an intact list of manufacturing establishments to serve as the frame for the MECS sample. Therefore, prior to discussing the MECS sample, the "frame" from which it was selected will be described in some detail.

A major responsibility of the Industry Division of the Census Bureau is to conduct the Census of Manufactures (CM) and the Annual Survey of Manufactures (ASM). The CM is conducted in those years ending in

[5]Office of Management and Budget, *Standard Industrial Classification Manual, 1972* (Washington, DC, 1972), p. 57.

"2" or "7" (for example, 1982), and provides economic data for the complete universe of approximately 350,000 manufacturing establishments in the United States. For the purposes of data collection, the CM universe is divided into two major subsets as follows.

1. **Small Single-Establishment Companies Not Sent a Report Form.** These companies are excused from filing a CM report. Generally, those with less than 5 employees are excused while all with more than 20 are mailed report forms. Those with 5 through 20 employees are excused or sent a report form based on the magnitude of their annual payroll and shipments data. Approximately 125,000 establishments are excused due to this criterion.

2. **Establishments Sent a Report Form.** The remaining manufacturing establishments in the universe are sent a report form.

The ASM is conducted during non-CM years to provide estimates of economic characteristics for the universe of manufacturing establishments. The ASM contains two components. The mail portion is a probability sample of manufacturing establishments selected from the list of establishments that are sent the CM report form (see above). Those establishments are weighted so that they represent the mail portion of the CM universe. There are approximately 56,000 manufacturing establishments in the ASM mail sample. Prior to mailing the ASM materials, the sample is updated by adding new manufacturing establishments and removing those that went out of business or out of scope.

The second component of the ASM is the nonmail portion of the CM. These small establishments are not sent an ASM questionnaire, but their contribution is estimated based on selected information obtained annually from other Federal agencies.

The mail portion of the 1985 ASM, in turn, serves as the frame for the MECS sample. Thus, the universe covered by the MECS is the same universe covered by the ASM mail sample (that is, active CM establishments that are sent a report form, plus establishments that began operations since the last CM).

Sample Design

The overall size of the MECS sample was set at approximately 12,000 establishments based upon available resources and preliminary estimates of sampling error. The desired sample was allocated among 30 industry-based strata consisting of the 10 most energy-consumptive four-digit SIC industries and the remaining portions of the 20 two-digit SIC industry groups. Because of random variability in the sample selection process, the actual sample contained 12,065 establishments. For the 10 most energy-consumptive industries, all 1,907 establishments in the 1984 ASM sample were included in the 1985 MECS sample with certainty. The remaining 10,158 establishments were sampled from the 20 two-digit groups in a pattern designed to keep sampling errors within pre-established bounds for estimates of total consumption and consumption of four types of energy: electricity, natural gas, residual oil, and coal.

The procedure for subselecting ASM sample establishments into the MECS sample was such that their overall probabilities of selection for the MECS were proportional to an estimated energy measure of size. The overall probabilities for selection of the MECS sample establishments ranged from 0.002 to 1.000.

The selection of the MECS sample is, therefore, a two-stage selection process, with the first stage being the selection of the ASM mail sample, and the second, being the subselection of the MECS sample from the ASM sample. Thus, a MECS sample establishment is selected conditional upon it having been selected into the ASM mail sample. Its probability of selection from the ASM sample is a conditional probability so that the *overall* probability of selection into the MECS sample is represented by the product of this conditional probability and its ASM selection probability.

Of the initial sample of 12,065 establishments, 381 were determined to be out of business or out of scope based on updating procedures used by the Census Bureau. Thus, a final sample of 11,684 establishments were mailed the consumption portion of the MECS. However, for Part II, the fuel-switching portion, only 8,750 establishments were mailed a questionnaire. (The responses from the full sample of 11,684 establishments were used to prepare the estimates in this report. Fuel-switching status was imputed for the cases that were not mailed Part II of the questionnaire. See Development of the Data Files and The Estimation Process in this appendix for details.)

There were two reasons for excluding 2,934 establishments from the mailing of the Part II questionnaire. The first reason relates to consistency between the data reported in Parts I and II, and to the timing of Part II. To estimate fuel-switching capability, it was necessary for the respondent to determine the energy quantities that had been consumed for the production of heat and power. Those consumption data had already been submitted by the respondent on the consumption portion of the survey. To assure consistency of reporting between Parts I and II, the respondent-reported consumption values from the consumption survey form (Part I) were preprinted onto the fuel-switchingsurvey form (Part II), prior to mailing. To meet the November 26, 1986, mailout date for the fuel-switching form, the fuel-switching sample was restricted to the establishments whose Part I survey forms had arrived at the Census Bureau as of November 6, 1986, and whose consumption data were judged to

be of acceptable quality. Establishments for which Part I responses were received subsequent to November 6 were not mailed a Part II questionnaire.

The second reason relates to reducing respondent burden. Those establishments listing electricity for heat and power consumpton as their only use of energy were excused from submitting a Part II questionnaire. Those establishments were generally small and belonged to industries with low-intensity energy use, and would not be expected to have the capability to consume alternative energy in place of electricity.

Fieldwork, Editing, and Quality Control

Returned questionnaires for Part II of the MECS were subjected to initial screening procedures for completeness, and incomplete forms or responses with obvious inconsistencies were set aside for review by industry specialists. Valid returned questionnaires were forwarded directly to check-in and then to data entry.

All forms that were incomplete or failed the initial screening procedures were carefully reviewed by the industry specialists. The specialists retrieved missing data and verified questionable items by telephone contact with the individual who completed the questionnaire. Once the forms were completed and verified, they were forwarded to check-in and to data entry.

The resulting MECS data file was then subjected to a series of computer edits. These edits included internal consistency checks, as well as checks for outliers in the distribution of individual variables. Records with failed edits were reviewed and followed up by industry specialists.

Development of the Data File

The estimates in this report were computed from a basic data file consisting of individual records for all establishments with a valid response to Part I, the consumption portion, of the MECS questionnaire. As noted previously (see Sample Design in this appendix), not all of the Part I respondents were mailed a Part II questionnaire. Therefore, the establishment records on the fuel-switching data file may be divided into four groups as follows:

1. Establishments that responded to Part I, the consumption portion, and Part II, the fuel-switching portion, of the MECS questionnaire.
2. Establishments that responded to Part I, but which were excluded from the Part II mailing because purchased electricity was the only type of energy reported in Part I.
3. Establishments that responded to Part I and were sent a Part II questionnaire, but which did not respond to Part II.
4. Establishments that were excluded because a response to Part I had not been received by November 6, 1986, but which submitted a Part I response subsequent to that date.

Each fuel-switching data record contained the quantities of purchased electricity, natural gas, distillate fuel oil, residual fuel oil, and coal and coke combined that were consumed onsite for heat, power, and internal generation of electricity in 1985, as reported on Part I of the survey. Thus, estimated total consumption values published in this fuel-switching report correspond exactly to analogous values published in the consumption report. (There were some cases where a respondent changed one or more of the preprinted values. During the editing process, those cases were followed up by an industry specialist and the entries were changed, as appropriate, on Part I and/or Part II.)

Those records for the respondents to Parts I and II of the survey (Group 1, above) contained fuel-switching information in addition to the consumption data. For those establishments that were not sent a Part II questionnaire because their only energy consumption was purchased electricity (Group 2), all electricity consumption was imputed as not switchable. The respondent-provided data for Group 1, and the imputed data from Group 2 were the basis for ascertained switching capability.

No fuel-switching information was available for the remaining records, that is, the nonrespondents to Part II (Group 3), and those excluded because a Part I questionnaire had not been received by November 6, 1986 (Group 4). For those two groups, fuel-switching capability was categorized as "not ascertained" for all consumption that would have been covered by Part II.

In addition to consumption and fuel-switching data, each record contained the following economic data:

- Value of shipments and receipts
- Value added by manufacturing
- Total employment.

Those economic data were not collected by the 1985 MECS, but were provided by the Census Bureau. This was made possible by designing the MECS sample as a subsample of the ASM, allowing direct linkage of the 1985 ASM economic data and MECS energy data at the establishment level.

Response to the Survey

A total of 8,206 establishments responded to Part II, the fuel-switching portion of the survey. To these were added 433 establishments which consumed only purchased electricity and were imputed to have zero ascertained switching capability. Thus, the total number of sample establishments in the data file with ascertained values of fuel-switching capability was 8,639, or 74 percent of the final sample (see Sample Design in Appendix A) of 11,684 establishments for Part I, the Consumption portion of the MECS. However, those 8,639 establishments represent approximately 85 percent of the total unweighted 1985 value of shipments and receipts of the establishments in the final sample.

Another measure of response is the proportion of estimated total energy consumption that was ascertained as switchable or nonswitchable by the survey. For purchased electricity, ascertained capability (switchable plus nonswitchable) accounts for 87 percent of the total estimated 1985 consumption. For natural gas, distillate, residual, and coal and coke combined, the percentages were 92, 79, 91, and 93 respectively. Those quantities can be calculated directly from the estimates provided in Tables 3 through 7 of this report by adding the ascertained switchable quantity (column 2) and the ascertained nonswitchable quantity (column 3) and comparing the sum to the quantity consumed (column 1).

The Estimation Process

Estimates in this report represent the entire population of manufacturers in the CM universe that were covered in the 1985 ASM mailing. Full representation is accomplished by weighting the data from the establishment records in the fuel-switching data file. Weighting is the process of multiplying the reported or imputed values by a case-specific constant designed to inflate the data from each sample case to that portion of the population which it represents.

As noted in the preceding section, the fuel-switching and consumption data files contained the same establishments. Accordingly, the weights used to inflate the fuel-switching sample cases were the same as the weights used to inflate the consumption sample cases. The first, basic factor in the MECS weights was the sampling weight, which accounted for the MECS sampling process. The sampling weight for a MECS sample case is the reciprocal of its overall probability of selection, that is, its probability of selection into the ASM and subsequent selection for the final MECS sample of 12,065 establishments.

Prior to producing the estimates, the MECS sampling weights were adjusted to account for nonresponse and noncoverage from Part I, the consumption portion of the survey. Noncoverage resulted from the exclusion of two groups of establishments from the frame. One group was those establishments that began operations in 1984 and continued through 1985. The other was establishments that ceased operations during 1985, but should have reported for the time that they were still in business.

Adjustment factors to account for nonresponse and noncoverage were calculated using the estimated 1984 consumption of purchased fuels and electricity. Basically, those factors are ratios of the estimated energy consumption of the population covered by the original MECS sample plus exclusions to the estimated energy consumption of the population covered by MECS respondents.

Because the nonresponding establishments and exclusions were not evenly distributed by SIC or by size of establishment (with respect to fuel consumption), a separate adjustment factor was calculated for large, medium, and small establishments within each of the 30 sampling strata. Within each of the 90 adjustment cells, the appropriate adjustment factor was then multiplied by the sampling weight for all responding MECS establishments. The product of the sampling weight and the adjustment factor is the final adjusted MECS weight, which is used to produce all MECS population estimates in this report. The adjustment factors, in effect, ratio adjust the weighted data from the MECS respondents to estimated totals for the universe that was initially targeted by the MECS frame and sample design, that is, manufacturers represented by the 1985 ASM mail sample.

Survey Estimates

All estimates of fuel-switching capability appearing in this report were calculated by combining the data collected from the sampled establishments with the adjusted sampling weights. Those weights establish the relationship between the responding establishments and the manufacturing sector as defined for the MECS.

Table 1 presents estimates of nonswitchable minimum requirements and the maximum consumption potential of the different types of energy covered by Part II of the MECS. An estimate of the actual consumption of each type of energy is provided as a reference point. That consumption estimate represents the quantity that was consumed onsite for the production of heat, power, and the generation of electricity in 1985.

One of the purposes of Table 1 is to provide an estimate of the quantity of a given type of energy that would have been required in 1985, after all possible ascertained switching away from that type of energy had taken place. The quantities given in the minimum con-

sumption column of Table 1 are likely to be higher than the true minimum energy requirements because they include the quantity of 1985 consumption for which switching capability was not ascertained. Some unknown proportion of this latter quantity could likely have been replaced.

Table 1 also provides estimates of the maximum energy consumption that would have been possible if the actual consumption had been maintained at its 1985 level and all ascertained switching to that type of energy had occurred. Two estimates of maximum consumption potential are provided. The "low" estimate assumes that when a type of energy was reported as an alternative for two or more other types of energy at an establishment, only a single substitution was possible at any one time. The substitutable amount consists of the single, largest switchable amount from any type of energy to the designated energy type. The "high" estimate assumes that all indicated substitutions were simultaneously possible and the substitutable amount consists of the sum of all possible switches to the designated type of energy.

The "low" and "high" estimation techniques may be illustrated by an example. Assume a respondent reported that the total consumption of natural gas for 1985 was 15 million cubic feet, and that 2 million and 5 million cubic feet of natural gas could have been consumed as alternatives for residual fuel oil and coal, respectively. The "low" estimate of the maximum consumption of natural gas for that respondent would have been 20 million cubic feet, and the "high" estimate would have been 22 million cubic feet.

Table 2 presents estimates of the 1985 quantities of specific types of energy that could have been switched to an alternate energy type, categorized by the time required to make that switch. The Part II questionnaire did not collect information on the minimum leadtime to convert to each possible alternative (see Appendix C). Rather, respondents were instructed to indicate the minimum leadtime required to convert to the primary replacement; that is, the alternative which could have replaced the largest quantity of the fuel that was actually consumed in 1985. If two or more replacements had equivalent substitutability, respondents were instructed to indicate the shortest leadtime among those replacements. The resulting estimates for each type of energy are shown in Table 2 in the row entries labeled "less than one day", "one day through one week", and "more than one week but within 30 days". The remaining row contains estimates of the quantities for which the leadtime was not ascertainable. For Part II respondents, that quantity represents the difference, if any, between the total quantity substitutable (see Row 3 of the questionnaire) and the amount that could have been replaced by the primary alternative, for which the minimum leadtime to switch was ascertainable.

Tables 3 through 7 present estimates of the capability of substituting specific alternative types of energy for those actually consumed. Each table contains information for the specific type of energy that was actually consumed for the production of heat, power, and generated electricity in 1985. It should be noted that the first column of Table 3 refers to "total *purchased* " electricity, while the first column of Tables 4 through 7 refer to "total *consumed* " natural gas, distillate fuel oil, residual fuel oil, and coal and coke, respectively. Thus, the quantities of electricity generated onsite are excluded as are the quantities of electricity transferred to or from the establishment site. Only purchased electricity was preprinted on the Part II questionnaire to (1) facilitate processing to meet the November 25, 1986, mailing deadline, and (2) to provide the respondent with an immediately recognizable quantity.

Tables 3 through 7 are divided into four panels. The first panel contains estimates for the 30 industrial strata used in the sample design and the second contains estimates by Census region. The third and fourth panels contain estimates by classes of value of shipments and employment size, respectively.

In Tables 3 through 7, the estimates provided in the columns labeled "alternative types of energy" should be read independently of each other because respondents were instructed to enter the *maximum* amount of the quantity of the energy actually consumed, which could have been replaced by a given alternative. For example, Table 4 shows that for Paper and Allied Products (SIC 26), a total of 238 billion cubic feet of natural gas was ascertained switchable. Purchased electricity could have replaced 11 billion cubic feet of that quantity. The other replacement quantities are distillate fuel oil, 88 billion cubic feet; residual fuel oil, 161 billion cubic feet; coal and coke, 6 billion cubic feet; LPG, 10 billion cubic feet; and other, 6 billion cubic feet. Because each value represents the maximum quantity of natural gas that could have been replaced, their sum exceeds the total quantity of natural gas that was ascertained as switchable. This difference indicates that some establishments had more than one type of energy that could have been substituted for natural gas usage during 1985.

Appendix B

Quality of the Data

Appendix B

Quality of the Data

Introduction

All data collection activities and the estimates produced from them are subject to a variety of errors. These errors may be broadly classified under two general types, sampling error and nonsampling error.

Sampling error is defined as the variability in a survey estimator that arises because data are collected from a sample of units rather than the entire population. Each possible sample produces different estimates of population parameters, depending on the set of respondents that are selected. Nonsampling errors, on the other hand, occur in any data collection activity, whether a sample survey or a complete census. Nonsampling errors are attributable to all aspects of the total survey design other than the sampling process, and can include both random and systematic (biasing) errors. Commonly recognized sources of nonsampling error include undercoverage, random and systematic response errors, nonresponse, data processing errors, and tabulation errors. This appendix describes the effect of both sampling and nonsampling errors on data from the MECS. More details are presented in the methodological report for the MECS.[6]

Sampling Error

The estimated values appearing in this report were developed from a sample of manufacturing establishments and, as a result, will differ from true population values that would be obtained from a complete census. This is because the MECS sample is only one of a very large number of samples that could have been selected under the same sampling specifications. Each possible sample would yield its own estimates of the true population values, with the differences attributable to the particular set of establishments selected into each sample.

One measure of variability due to sampling is the average difference between the estimates that would be produced by all possible samples and the mean value of these estimates. This type of measure is commonly known as sampling error. Estimates of the magnitude of these sampling errors based on data from a single sample are provided by a statistic known as the standard error of an estimate. Standard errors for MECS estimates are computed from the reported data using the formula:

$$S_{\hat{Y}} = \sqrt{\sum_{i=1}^{n} y_i^2 (W_i)(W_i - 1)} , \qquad (1)$$

where $\hat{Y} = \Sigma y_i \cdot W_i$ is the MECS survey estimator, y_i is the reported value of characteristic Y for the i^{th} MECS sample case, W_i is the final adjusted weight used to inflate the sample data to population estimates, and n is the number of MECS respondents. Justification for this formula is found in the MECS methodological report.

Estimates of standard errors have been computed from the MECS sample data for the estimated aggregate values and ratios appearing in this report. They are presented in the form of relative standard errors (RSE), that is, the standard error divided by the estimated value to which it refers. The RSE's are given in Tables B1 through B7 of this appendix.

The estimates in this report can be used to produce proportion statistics based on the ratio of various estimates reported in Tables 1 through 7. Proportions are not given in the detailed tables but are used in the summary of findings to clarify the analysis. A proportion is the statistic of the form

$$\hat{P} = \frac{\hat{Y}}{\hat{X}} , \qquad (2)$$

where $\hat{Y}$ and $\hat{X}$ are survey-based estimates of aggregate parameters Y and X, respectively, and characteristic X "encompasses" characteristic Y. That is, each population element (and, thus, each sample case) that contrib-

[6]Energy Information Administration, *Manufacturing Energy Consumption Survey: Methodological Report,* DOE/EIA-0514 (Washington, DC, 1988).

utes to Y also contributes to X, and the value of X for each element is greater than or equal to the value of Y.

The RSE's of those proportion statistics are not included in Tables B1 through B7. However, the RSE's of aggregate statistics can be used to produce approximate errors for them. The straightforward additive error formula shown in (1) gives rise to a similarly straightforward upper bound approximation to the error of an estimated proportion. The approximation can be expressed in terms of relative error as

$$RSE(\hat{P}) \leqq \sqrt{[RSE(\hat{Y})]^2 \cdot (1 - 2\hat{P}) + [RSE(\hat{X})]^2} \quad . (3)$$

Justification for this formula is found in the MECS methodological report.

Basically, these RSE's can be used to evaluate how precisely a given sample statistic estimates the corresponding population parameter. The larger the RSE, the less precise the estimate. For example, the minimum consumption potential of natural gas by the manufacturing sector for 1985 was estimated to be 2,618 billion cubic feet (Table 1), and that estimate has a RSE of 2 percent (Table B1). Similarly, the minimum consumption potential of natural gas in the Northeast Census Region was estimated to be 235 billion cubic feet with an associated RSE of 4 percent. The estimate of minimum natural gas consumption potential in the Northeast Census Region is relatively less precise than the estimate for the entire United States, primarily because, all other things being equal, larger samples result in smaller RSE's. Naturally, the MECS sample for the entire United States is larger than the sample for the Northeast Census Region.

Confidence intervals can also be developed from an estimate and its associated RSE using the central limit theorem to claim normal distribution properties for the MECS estimator. A confidence interval is a range of values which, due to its method of construction, has a known probability of containing the true, but unknown population parameter with repeated sampling. Confidence intervals are formed by adding and subtracting multiples of the standard error from the estimate, and are an alternative method of expressing precision.

Again, for the example of minimum natural gas consumption potential of 2,618 billion cubic feet in the United States and its associated RSE of 2 percent, the standard error is approximately 52 billion cubic feet (2 percent of 2,618 quadrillion Btu). The estimated value plus and minus one standard error will provide a range that includes the true population parameter for about 68 percent of all samples. The 68 percent confidence interval for minimum natural gas consumption potential is 2,618 billion cubic feet ±52, or 2,566 to 2,670 billion cubic feet. The estimated value plus and minus two standard errors includes the true population parameter for about 95 percent of all samples. The 95 percent confidence interval is 2,514 to 2,722 billion cubic feet. Finally, a confidence interval formed by the estimated value plus and minus three standard errors provides more than 99 percent confidence that the range contains the true population parameter. The 99 percent confidence interval for estimated minimum natural gas consumption potential is 2,462 to 2,774 billion cubic feet.

Standard errors may also be used to compare two or more survey estimates. For example, the estimated quantity of switchable natural gas for the Paper and Allied Products Industries (SIC 26) in 1985 was 238 billion cubic feet, and the estimate for the Primary Metal Industries (SIC 33) was 247 billion cubic feet (Table 4). The relative standard errors (Table B4) for these estimates are 5 and 3 percent, respectively.

From a comparison of these two estimates, one might conclude that SIC 33 had slightly more potential for switching away from natural gas than did SIC 26. This may not be a valid conclusion, however, because the difference between the two estimates may be due to sampling variability rather than to a difference in the true population values. Such comparisons, therefore, are subject to statistical testing.

The appropriate statistical test is the standard normal deviate test. By appeal to the central limit theorem, this test assumes that a sampling distribution of the differences between two estimates is normal. The test is most appropriate when the distributions of the two estimates in question are independent. Therefore, it can be used to test for differences between industrial strata, geographic regions, etc.[7] The test statistic is given as:

$$Z_{\hat{X}-\hat{Y}} = \frac{\hat{X} - \hat{Y}}{\sqrt{S^2_{\hat{X}} + S^2_{\hat{Y}}}} \quad , \qquad (4)$$

where $\hat{X}$ and $\hat{Y}$ are the survey estimates of the population values X and Y, respectively, and $S_{\hat{X}}$ and $S_{\hat{Y}}$ are the estimated standard errors. The test statistic, $Z_{\hat{X}-\hat{Y}}$ is then compared to a predetermined critical value, Z_C, and if the value of the test statistic exceeds the critical value, the hypothesis of no difference is rejected in favor of the alternative. If, on the other hand, the test statistic is equal to or less than the the critical value, the hypothesis of no difference is not rejected, and it is concluded that the evidence provided by the sample data does not support the alternative hypothesis.

[7]For a more complete discussion of the central limit theorem and the standard normal deviate test, the reader is referred to any introductory statistics textbook.

Ordinarily, the critical value, Z_C, is set so that the level of significance of the test is .05 (that is, the probability of incorrectly detecting a significant difference is .05). Two values correspond to this level of significance -- 1.96 and 1.65. The former is the appropriate value when the test is nondirectional, that is, when the relevant question is, "Is there any difference in the two population values?" In this case, the absolute value of the test statistic $Z_{\hat{X}-\hat{Y}}$, would be compared to 1.96.

The value of 1.65 is appropriate when the test is directional, that is, when the relevant question is, "Is one population value greater than the other?" In this case, the true value of the test statistic would be compared to 1.65.

Returning to the previous example, the standard errors for the estimates of switchable natural gas consumption in SIC 26 and SIC 33 are 12 billion cubic feet (5 percent of 238 billion cubic feet) and 7 billion cubic feet (3 percent of 247 cubic feet), respectively. The test is directional because the relevant question is, "Is the switching potential of natural gas in SIC 33 greater than the switching potential of natural gas in SIC 26?", and the relevant critical value is 1.65. The test statistic is computed as:

$$Z_{\hat{X}-\hat{Y}} = \frac{247 - 238}{\sqrt{12^2 + 7^2}} = \frac{9}{13.9} = 0.7. \quad (5)$$

Because the value of $Z_{\hat{X}-\hat{Y}}$ does not exceed the critical value of 1.65, it must be concluded that there is insufficient sample evidence to reject the null hypothesis, and that there is no difference between the true population values. Based upon the results of this test, the sample estimates do not support the conclusion that SIC 33 had a greater potential for switching away from natural gas than did SIC 26, and a statement such as that should be avoided.

Finally, situations may arise in which it is desirable to compare more than two estimates. For example, one might wish to state "The four Census regions in decreasing order of switchable natural gas are: the South with 843 billion cubic feet, the Midwest with 563 billion cubic feet, the West with 257 billion cubic feet, and the Northwest with 232 billion cubic feet." Before such a statement can be made, it is necessary to determine whether all possible pairs of estimates are significantly different in the stated direction. The number of possible comparisons among the four Census regions is given as the combinatorial ${}_4C_2 = 6$. Conducting each test at a .05 level of significance results in a probability of incorrectly detecting at least one significant difference, when none in fact exist, of $1-(1-.05)^6 = 0.26$. This overall probability can be kept within .05 by conducting each test at $.05/6 = .0083$ level of significance, which has a corresponding critical value of 2.40 for a directional test. The following table lists the appropriate critical values for up to 10 directional and nondirectional multiple hypothesis tests. These critical values result in an overall level of significance of .05.

Suggested Critical Values for Multiple Hypothesis Test

Number of Comparisons	Directional Tests	Nondirectional Tests
1	1.65	1.96
2	1.96	2.24
3	2.13	2.39
4	2.24	2.50
5	2.33	2.58
6	2.39	2.64
7	2.45	2.70
8	2.50	2.74
9	2.54	2.77
10	2.58	2.81

Nonsampling Errors and Bias

Nonsampling errors that affect MECS fuel-switching data can be divided into three major categories:

1. **Operational errors**, including editing, coding, and tabulation errors.
2. **Errors of measurement**, including a lack of precision by the respondent, failure of the respondent to understand instructions, etc..
3. **Errors of nonobservation**, including nonresponse and noncoverage.

These errors are collectively referred to as nonsampling errors because they are not related to the sampling process, and thus would be equally likely to occur in a complete census or a sample survey.

It is felt that operational errors are not a major concern for the estimates included in this report. The quality control procedures that were employed for check-in, editing, coding and keying the returned questionnaires (see Appendix A) are standard procedures that are in place at the Bureau of the Census and have withstood the test of time. Data tabulations were verified by comparing marginal totals in tables generated from files supplied to EIA with corresponding totals generated directly from microdata files held at the Census Bureau.

Errors of measurement are a concern in any data collection activity. The survey results for the MECS were subjected to extensive editing procedures which were

specifically designed to detect errors of measurement. Responses that failed these tests for reasonableness and consistency were recalled by analysts familiar with manufacturing processes and energy use. Major errors, including omissions and misreporting by orders of magnitude, were corrected. No editing procedure is capable of identifying all measurement errors, however, and some small errors will remain. To the extent that these errors are due to random, rather than systematic misjudgments, they are compensating in the aggregate totals presented in this report, and it is believed that there are few large systematic biases that result from them.

Finally, several potential sources of nonsampling error and bias result from errors of nonobservation. One source of noncoverage error results from the MECS target universe not being identical to the total manufacturing universe. As previously described, the population of interest for the MECS is the same universe covered by the ASM mail sample (Appendix A). That target universe excludes very small establishments, and thus, noncoverage represents a source of bias with respect to estimated energy consumption by the universe of manufacturing establishments. The effect of this noncoverage is generally not large (estimated only to be a few percent for most industry groups) because energy consumption is highly concentrated among the larger manufacturing establishments, and the MECS sample was specifically designed to capture those establishments with substantial energy consumption. Nevertheless, users should be aware of this noncoverage bias when attempting to relate the MECS estimates to the universe of all manufacturing establishments.

In addition, Appendix A describes the adjustments that were made to the MECS sampling weights to account for nonresponse and noncoverage of specific portions of the MECS target universe. Basically, the procedure was to ratio adjust the weighted data from the MECS respondents to the estimated totals for the universe that was initially targeted by the MECS frame and sample design. Clearly, had these adjustments not been performed, the estimates produced from only the responding establishments would not have been representative of the target universe for the MECS. Such estimates would potentially have been biased. Adjusting the sampling weights to reflect the target universe is an attempt to mitigate the potential effects of such a bias.

As described in Appendix A, separate adjustment factors were developed by size of establishment within sampling strata, resulting in 90 separate adjustment factors. Adjustment factors were calculated for each of the 90 cells using estimated 1984 fuel consumption for heat and power. Each cell represents a relatively homogeneous subgrouping of establishments with respect to primary output and level of fuel consumption. Implicit in that procedure is the assumption that primary output and level of fuel consumption are highly correlated with energy consumption patterns, so that the establishments within a cell would also be homogeneous with respect to the quantities, types, and shares of energy consumed as fuels and for nonfuel purposes.

To the extent that the nonresponding establishments within the adjustment cells share the energy consumption patterns of the responding establishments within those cells, the resulting adjustments to the MECS estimates will tend to be minimally biased. If, on the other hand, the energy consumption patterns of the responding and nonresponding establishments differ substantially, the resulting adjustments are potentially biased, and may not represent the originally targeted MECS universe.

That approach to adjustment for nonresponse and noncoverage was *not* extended to account for the part of the population represented by respondents to MECS Part I who did not complete Part II of the survey. Fuel-switching capability as measured by the MECS was a new, relatively complex concept whose degree of penetration was expected to be quite variable and unpredictable, especially in certain industries. Also, it seemed highly possible that the later respondents to Part I, who were not included in the sample for Part II, may not have been at all like earlier respondents to Part I with regard to fuel switching capability, for reasons associated with their delayed response to Part I. For these reasons, supplemental weight adjustment, which assumes that the unrepresented part of the population in an adjustment cell is like the part represented by survey respondents, was not considered appropriate. Item imputation for Part I respondents without Part II data was also rejected, for the same reasons.

The final disposition of those incomplete cases was to classify all reported consumption from Part I that belonged in Row 1 of the Part II questionnnaire into a "not ascertained" category of fuel-switching capability. The only exception to this procedure was for establishments excused from Part II because their only reported consumption for heat and power in Part I was purchased electricity. All consumption for those cases was classified as nonswitchable, since they were, for the most part, small establishments in less energy-intensive industries. Such establishments were presumed to have neither the physical capability nor the motivation to switch away from their electricity use.

To the extent that some of that consumption may be switchable, the procedure for all-electric establishments represents a negative bias in switchable consumption of electricity. However, the effect is most like negligible, because the weighted total electricity consumption of these establishments represents only a few percent of the national total, and the substitutability of electricity among respondents to Part II was very low.

The larger issue, of course, is the amount of substitution capability embedded in the "not ascertained" category.

That category encompasses a substantial proportion of total consumption in main population subgroups, and it is reasonable to expect that some part of it would have been classified as substitutable if responses to Part II of the MECS had been obtained from all respondents to Part I. As explained earlier, the extent of substitutability in this category is very uncertain. Large errors in assigning substitutability could rival, or even exceed sampling error in some population subgroups. Therefore, all analyses in this report are based on estimates of ascertained switching capability. No attempt has been made to adjust these values to account for substitutability in the "not ascertained" category. The reader is advised to be extemely careful in attempting to produce any such adjustment.

More detailed information on sources of nonsampling error in the MECS can be found in the methodological report. Tables B1 through B7 on the following pages contain estimated relative standard errors for the estimated quantities presented in Tables 1 through 7.

Table B1. Relative Standard Errors for Table 1 of Detailed Statistics Section
(Percent)

Type of Energy	Actual Consumption	Minimum Consumption	Maximum Consumption	
			Low Estimate	High Estimate
Total United States				
Purchased Electricity	2	2	2	2
Natural Gas	2	2	1	1
Distillate Fuel Oil	6	6	2	2
Residual Fuel Oil	3	3	2	2
Coal and Coke	3	3	3	3
Northeast Census Region				
Purchased Electricity	3	3	3	3
Natural Gas	3	4	3	3
Distillate Fuel Oil	8	9	4	4
Residual Fuel Oil	4	4	3	3
Coal and Coke	8	9	8	8
Midwest Census Region				
Purchased Electricity	4	4	4	4
Natural Gas	2	3	2	2
Distillate Fuel Oil	13	15	4	4
Residual Fuel Oil	7	7	3	3
Coal and Coke	4	4	4	4
South Census Region				
Purchased Electricity	2	2	2	2
Natural Gas	2	3	2	2
Distillate Fuel Oil	11	10	3	3
Residual Fuel Oil	4	5	3	3
Coal and Coke	3	4	3	3
West Census Region				
Purchased Electricity	4	4	4	4
Natural Gas	3	4	3	3
Distillate Fuel Oil	8	9	5	5
Residual Fuel Oil	5	7	4	4
Coal and Coke	6	9	6	6

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846(S), "1985 Manufacturing Energy Consumption Survey: Part II--Fuel-Switching Capability."

Table B2. Relative Standard Errors for Table 2 of Detailed Statistics Section
(Percent)

Type of Energy and Minimum Leadtime to Switch	Quantity Switchable				
	Total United States	Census Region			
		Northeast	Midwest	South	West
Purchased Electricity					
Less than one day	6	12	10	8	19
One day through one week	8	14	26	10	16
More than one week but within 30 days	11	43	26	15	15
Leadtime not ascertainable	27	47	37	21	Q
Total	4	10	9	6	11
Natural Gas					
Less than one day	2	6	3	3	6
One day through one week	3	5	4	4	6
More than one week but within 30 days	3	7	4	5	9
Leadtime not ascertainable	4	9	5	5	14
Total	2	4	2	2	4
Distillate Fuel Oil					
Less than one day	11	14	13	23	30
One day through one week	41	16	28	Q	18
More than one week but within 30 days	18	25	45	19	19
Leadtime not ascertainable	33	Q	Q	Q	24
Total	15	13	18	33	22
Residual Fuel Oil					
Less than one day	4	6	6	6	7
One day through one week	7	9	15	10	11
More than one week but within 30 days	7	12	W	W	18
Leadtime not ascertainable	15	16	W	W	22
Total	4	5	9	6	4
Coal and Coke					
Less than one day	4	5	6	5	10
One day through one week	4	13	7	4	15
More than one week but within 30 days	12	9	33	8	26
Leadtime not ascertainable	9	11	8	16	26
Total	3	5	6	4	8

W=Withheld to avoid disclosing data for individual companies. Data are included in higher level totals.
Q=Relative standard error greater than or equal to 50 percent.
Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846(F), "1985 Manufacturing Energy Consumption Survey: Part II–Fuel-Switching Capability."

Table B3. Relative Standard Errors for Table 3 of Detailed Statistics Section
(Percent)

Selected Characteristics		Purchased Electricity			Alternative Types of Energy					
		Total Purchased	Switchable	Not Switchable	Natural Gas	Distillate Fuel Oil	Residual Fuel Oil	Coal and Coke	LPG	Other
SIC Code[a] and Industries										
20	Food and Kindred Products	4	18	4	22	29	16	31	Q	Q
21	Tobacco Manufactures	6	W	6	Q	W	0	0	0	0
22	Textile Mill Products	3	22	4	W	Q	Q	W	0	Q
23	Apparel and Other Textile Products	8	Q	9	0	Q	0	0	0	0
24	Lumber and Wood Products	7	37	8	Q	Q	W	0	Q	41
25	Furniture and Fixtures	7	Q	8	Q	0	0	0	0	Q
26	Paper and Allied Products	3	8	3	10	17	9	13	Q	18
2621	*Paper Mills, Except Building Paper*	4	10	4	12	W	10	14	0	18
2631	*Paperboard Mills*	7	15	8	18	35	19	28	0	0
27	Printing and Publishing	7	29	8	27	34	Q	0	Q	0
28	Chemicals and Allied Products	6	13	6	19	42	28	W	43	W
2819	*Industrial Inorganic Chemicals*	18	24	19	29	35	45	37	0	*
2821	*Plastics Materials and Resins*	3	7	3	W	8	9	0	0	0
2869	*Industrial Organic Chemicals*	2	5	2	6	6	W	0	W	W
2873	*Nitrogenous Fertilizers*	9	7	10	W	W	0	0	0	0
29	Petroleum and Coal Products	3	6	4	6	10	7	42	7	16
2911	*Petroleum Refining*	4	6	4	6	10	7	W	7	16
30	Rubber and Misc. Plastics Products	5	37	5	Q	22	Q	0	Q	Q
31	Leather and Leather Products	19	43	24	W	0	0	Q	0	0
32	Stone, Clay and Glass Products	3	41	3	Q	26	0	0	46	Q
3241	*Cement, Hydraulic*	4	22	5	22	0	0	0	0	0
33	Primary Metal Industries	4	9	4	10	17	11	29	Q	W
3312	*Blast Furnaces and Steel Mills*	4	10	4	10	W	11	0	0	W
3334	*Primary Aluminum*	8	W	8	W	W	0	0	0	0
34	Fabricated Metal Products	5	43	5	30	47	20	W	Q	Q
35	Machinery, Except Electrical	4	37	5	32	18	19	0	Q	Q
36	Electric and Electronic Equipment	4	28	5	28	43	Q	15	Q	0
37	Transportation Equipment	3	16	3	21	16	W	W	W	0
38	Instruments and Related Products	9	15	10	Q	Q	14	W	0	0
39	Misc. Manufacturing Industries	7	Q	8	Q	Q	Q	0	0	0
	Total	2	4	2	5	9	6	10	10	13
Census Region										
Northeast		3	10	3	14	32	9	11	45	18
Midwest		4	9	4	11	17	13	15	18	23
South		2	6	2	6	12	8	13	14	19
West		4	11	4	13	22	17	44	14	20
Total		2	4	2	5	9	6	10	10	13
Value of Shipments[b] (million dollars)										
Under 20		3	20	4	25	32	36	46	46	Q
20-49		3	17	3	25	39	38	W	Q	26
50-99		3	14	3	15	22	15	W	W	23
100-249		3	9	3	11	15	11	17	47	22
250-499		5	7	5	9	11	7	18	11	W
500 and Over		6	5	6	5	11	8	16	8	15
Total		2	4	2	5	9	6	10	10	13
Employment Size[b]										
Under 50		6	36	7	42	Q	47	Q	Q	Q
50-99		4	26	5	34	32	47	Q	Q	Q
100-249		3	15	3	19	29	33	48	28	44
250-499		2	9	3	10	27	12	18	12	17
500-999		3	7	3	8	13	8	18	10	14
1,000 and Over		4	5	4	6	11	8	12	12	W
Total		2	4	2	5	9	6	10	10	13

[a] See Appendices A and D for descriptions of the Standard Industrial Classification system.
[b] Value of Shipments and Employment Size were supplied by the Bureau of the Census. See Appendix A.
*=Corresponding estimate in Detailed Statistics Tables is less than 0.5 rounded to zero.
W=Withheld to avoid disclosing data for individual companies. Data are included in higher level totals.
Q=Relative standard error greater than or equal to 50 percent.
Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846(S), "1985 Manufacturing Energy Consumption Survey: Part II--Fuel-Switching Capability."

Table B4. Relative Standard Errors for Table 4 of Detailed Statistics Section
(Percent)

Selected Characteristics		Natural Gas			Alternative Types of Energy					
		Total Consumed	Switchable	Not Switchable	Purchased Electricity	Distillate Fuel Oil	Residual Fuel Oil	Coal and Coke	LPG	Other
SIC Code[a] and Industries										
20	Food and Kindred Products	3	3	6	33	5	4	12	8	28
21	Tobacco Manufactures	11	13	16	0	34	16	0	*	Q
22	Textile Mill Products	4	4	7	Q	7	5	8	9	0
23	Apparel and Other Textile Products	12	16	13	Q	18	23	*	38	Q
24	Lumber and Wood Products	8	12	13	0	19	24	0	20	Q
25	Furniture and Fixtures	8	14	10	Q	23	40	Q	16	Q
26	Paper and Allied Products	4	5	7	15	7	6	19	11	29
2621	*Paper Mills, Except Building Paper*	4	5	5	17	7	6	19	24	*
2631	*Paperboard Mills*	9	9	16	33	14	11	23	36	32
27	Printing and Publishing	7	11	11	42	17	37	0	16	*
28	Chemicals and Allied Products	2	3	3	17	4	4	11	5	13
2819	*Industrial Inorganic Chemicals*	10	10	13	*	10	16	44	25	Q
2821	*Plastics Materials and Resins*	W	5	6	Q	9	5	*	W	W
2869	*Industrial Organic Chemicals*	4	3	5	W	4	3	9	5	9
2873	*Nitrogenous Fertilizers*	3	7	4	0	7	9	0	*	*
29	Petroleum and Coal Products	4	5	6	9	8	6	25	7	12
2911	*Petroleum Refining*	5	5	6	9	9	6	22	7	12
30	Rubber and Misc. Plastics Products	4	5	9	*	5	5	*	22	Q
31	Leather and Leather Products	15	17	22	Q	11	9	0	Q	0
32	Stone, Clay and Glass Products	3	4	6	32	5	8	18	5	Q
3241	*Cement, Hydraulic*	8	12	11	0	8	24	20	*	0
33	Primary Metal Industries	3	3	4	19	5	5	12	5	18
3312	*Blast Furnaces and Steel Mills*	4	4	4	W	6	5	13	9	W
3334	*Primary Aluminum*	W	9	13	0	11	20	0	10	32
34	Fabricated Metal Products	5	8	6	19	15	9	11	11	46
35	Machinery, Except Electrical	5	6	8	26	9	10	26	11	*
36	Electric and Electronic Equipment	3	5	5	22	6	7	*	8	*
37	Transportation Equipment	3	3	4	20	5	5	9	7	13
38	Instruments and Related Products	9	10	16	Q	12	13	0	26	0
39	Misc. Manufacturing Industries	9	12	12	0	16	23	*	14	Q
	Total	2	2	2	7	2	2	6	3	9
Census Region										
Northeast		3	4	4	14	5	6	19	6	21
Midwest		2	2	3	9	4	3	7	4	20
South		2	2	3	9	4	3	12	5	11
West		3	4	5	24	6	5	24	6	18
Total		2	2	2	7	2	2	6	3	9
Value of Shipments[b] (million dollars)										
Under 20		3	5	5	20	6	8	25	8	42
20-49		2	3	3	21	5	5	13	6	34
50-99		2	3	3	22	4	5	12	5	25
100-249		2	3	3	12	4	4	12	4	25
250-499		3	4	4	14	4	5	10	5	11
500 and Over		3	4	4	10	7	4	9	6	12
Total		2	2	2	7	2	2	6	3	9
Employment Size[b]										
Under 50		5	8	7	31	11	12	Q	16	Q
50-99		4	6	5	29	7	9	39	11	39
100-249		3	3	4	28	4	5	14	6	30
250-499		2	3	3	16	4	4	11	4	22
500-999		3	3	4	10	5	4	9	5	10
1,000 and Over		3	3	4	11	5	4	7	6	21
Total		2	2	2	7	2	2	6	3	9

[a] See Appendices A and D for descriptions of the Standard Industrial Classification system.
[b] Value of Shipments and Employment Size were supplied by the Bureau of the Census. See Appendix A.
*=Corresponding estimate in Detailed Statistics Tables is less than 0.5 rounded to zero.
W=Withheld to avoid disclosing data for individual companies. Data are included in higher level totals.
Q=Relative standard error greater than or equal to 50 percent.
Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846(S), "1985 Manufacturing Energy Consumption Survey: Part II–Fuel-Switching Capability."

Table B5. Relative Standard Errors for Table 5 of Detailed Statistics Section
(Percent)

Selected Characteristics		Distillate Fuel Oil			Alternative Types of Energy					
		Total Consumed	Switchable	Not Switchable	Purchased Electricity	Natural Gas	Residual Fuel Oil	Coal and Coke	LPG	Other
SIC Code[a] and Industries										
20	Food and Kindred Products	22	43	18	Q	21	29	Q	Q	0
21	Tobacco Manufactures	29	Q	W	0	Q	15	0	15	*
22	Textile Mill Products	24	48	22	Q	Q	38	Q	38	*
23	Apparel and Other Textile Products	16	Q	22	0	Q	Q	0	0	0
24	Lumber and Wood Products	20	31	24	Q	38	W	0	Q	Q
25	Furniture and Fixtures	20	43	22	Q	Q	Q	Q	Q	Q
26	Paper and Allied Products	9	13	13	Q	15	31	20	43	W
2621	*Paper Mills, Except Building Paper*	9	12	11	0	15	20	23	W	W
2631	*Paperboard Mills*	10	19	13	*	23	45	24	45	0
27	Printing and Publishing	21	35	27	Q	36	Q	0	Q	0
28	Chemicals and Allied Products	11	16	17	36	16	28	W	Q	17
2819	*Industrial Inorganic Chemicals*	14	39	15	0	40	35	0	21	Q
2821	*Plastics Materials and Resins*	11	18	4	*	18	*	W	0	W
2869	*Industrial Organic Chemicals*	34	48	44	0	3	7	10	Q	*
2873	*Nitrogenous Fertilizers*	6	8	7	0	8	W	0	0	0
29	Petroleum and Coal Products	18	25	26	Q	34	34	Q	23	W
2911	*Petroleum Refining*	12	14	18	24	W	W	24	18	W
30	Rubber and Misc. Plastics Products	W	23	21	Q	22	44	0	24	0
31	Leather and Leather Products	41	Q	Q	0	Q	Q	Q	Q	0
32	Stone, Clay and Glass Products	15	30	21	Q	34	29	29	13	Q
3241	*Cement, Hydraulic*	6	14	7	W	16	27	0	W	0
33	Primary Metal Industries	7	16	7	Q	11	W	W	Q	Q
3312	*Blast Furnaces and Steel Mills*	5	9	5	0	10	W	0	W	0
3334	*Primary Aluminum*	12	W	13	0	W	0	0	32	0
34	Fabricated Metal Products	13	26	17	Q	27	Q	0	Q	Q
35	Machinery, Except Electrical	12	21	14	40	23	32	Q	Q	0
36	Electric and Electronic Equipment	W	19	20	Q	22	42	W	Q	Q
37	Transportation Equipment	7	10	9	18	14	W	W	18	Q
38	Instruments and Related Products	W	37	27	Q	39	Q	0	0	0
39	Misc. Manufacturing Industries	17	34	23	0	45	Q	0	0	0
	Total	6	15	7	40	10	17	27	Q	39
Census Region										
	Northeast	8	13	11	26	16	26	32	33	Q
	Midwest	13	18	17	Q	22	44	Q	32	Q
	South	11	33	12	38	18	18	Q	Q	40
	West	8	22	10	24	23	41	21	26	24
	Total	6	15	7	40	10	17	27	Q	39
Value of Shipments[b] (million dollars)										
	Under 20	9	27	12	Q	19	28	Q	Q	Q
	20-49	9	13	12	49	13	26	28	39	45
	50-99	7	10	10	37	11	22	15	39	*
	100-249	W	7	7	31	8	16	22	20	11
	250-499	W	8	6	48	9	7	14	28	W
	500 and Over	W	9	5	W	12	12	W	18	W
	Total	6	15	7	40	10	17	27	Q	39
Employment Size[b]										
	Under 50	14	40	16	Q	27	37	Q	Q	Q
	50-99	15	24	23	Q	28	47	37	48	Q
	100-249	10	12	14	Q	14	20	26	48	Q
	250-499	11	23	14	48	25	35	15	44	Q
	500-999	5	8	6	13	10	17	20	17	30
	1,000 and Over	4	6	4	20	7	13	11	16	20
	Total	6	15	7	40	10	17	27	Q	39

[a] See Appendices A and D for descriptions of the Standard Industrial Classification system.
[b] Value of Shipments and Employment Size were supplied by the Bureau of the Census. See Appendix A.
*=Corresponding estimate in Detailed Statistics Tables is less than 0.5 rounded to zero.
W=Withheld to avoid disclosing data for individual companies. Data are included in higher level totals.
Q=Relative standard error greater than or equal to 50 percent.
Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846(S), "1985 Manufacturing Energy Consumption Survey: Part II--Fuel-Switching Capability."

Table B6. Relative Standard Errors for Table 6 of Detailed Statistics Section
(Percent)

Selected Characteristics		Residual Fuel Oil			Alternative Types of Energy					
		Total Consumed	Switchable	Not Switchable	Purchased Electricity	Natural Gas	Distillate Fuel Oil	Coal and Coke	LPG	Other
SIC Code[a] and Industries										
20	Food and Kindred Products	7	8	11	W	8	17	40	33	0
21	Tobacco Manufactures	7	11	9	0	11	0	0	Q	Q
22	Textile Mill Products	7	10	13	Q	11	29	11	Q	Q
23	Apparel and Other Textile Products	29	34	Q	0	Q	40	0	0	0
24	Lumber and Wood Products	W	24	30	0	37	19	0	0	0
25	Furniture and Fixtures	20	23	32	0	12	36	0	0	0
26	Paper and Allied Products	W	7	5	19	7	14	16	28	17
2621	*Paper Mills, Except Building Paper*	5	9	7	W	9	15	20	W	20
2631	*Paperboard Mills*	10	15	13	45	15	38	40	Q	0
27	Printing and Publishing	W	Q	20	0	Q	Q	0	Q	0
28	Chemicals and Allied Products	5	7	7	20	6	16	21	W	38
2819	*Industrial Inorganic Chemicals*	11	15	17	37	21	19	30	0	0
2821	*Plastics Materials and Resins*	4	5	7	0	5	7	0	W	W
2869	*Industrial Organic Chemicals*	W	11	18	0	13	5	W	0	W
2873	*Nitrogenous Fertilizers*	W	W	0	0	W	W	0	0	0
29	Petroleum and Coal Products	7	8	10	10	9	11	W	9	14
2911	*Petroleum Refining*	7	8	10	10	9	11	W	9	14
30	Rubber and Misc. Plastics Products	7	7	15	0	7	10	W	Q	0
31	Leather and Leather Products	13	12	20	0	13	W	0	0	0
32	Stone, Clay and Glass Products	13	15	25	0	11	24	16	W	0
3241	*Cement, Hydraulic*	W	35	W	0	46	17	W	0	0
33	Primary Metal Industries	7	10	8	W	11	23	W	W	W
3312	*Blast Furnaces and Steel Mills*	8	10	8	W	12	W	W	W	W
3334	*Primary Aluminum*	W	W	0	0	W	W	0	0	0
34	Fabricated Metal Products	12	17	18	W	15	41	W	47	0
35	Machinery, Except Electrical	14	20	18	Q	16	28	W	Q	0
36	Electric and Electronic Equipment	8	11	13	Q	11	19	W	W	0
37	Transportation Equipment	5	6	6	15	8	9	W	W	W
38	Instruments and Related Products	W	15	11	0	13	23	0	0	0
39	Misc. Manufacturing Industries	17	17	11	Q	12	26	0	0	0
	Total	3	4	3	7	4	6	8	8	10
Census Region										
Northeast		4	5	5	13	5	9	14	15	14
Midwest		7	9	7	47	10	12	13	17	20
South		4	5	6	12	6	10	13	13	20
West		5	6	8	11	6	12	23	9	13
Total		3	4	3	7	4	6	8	8	10
Value of Shipments[b] (million dollars)										
Under 20		8	11	13	Q	12	18	30	Q	Q
20-49		6	9	8	37	8	14	23	48	20
50-99		5	8	7	17	6	14	21	19	13
100-249		5	5	7	19	6	8	12	12	21
250-499		5	6	7	W	4	15	13	11	W
500 and Over		5	7	6	8	8	11	15	10	14
Total		3	4	3	7	4	6	8	8	10
Employment Size[b]										
Under 50		16	23	23	W	27	30	0	0	Q
50-99		11	13	24	W	14	22	Q	19	46
100-249		5	7	7	22	6	11	18	12	*
250-499		5	6	7	25	5	14	10	10	24
500-999		4	6	6	13	6	12	17	16	12
1,000 and Over		4	6	5	9	7	10	9	15	15
Total		3	4	3	7	4	6	8	8	10

[a] See Appendices A and D for descriptions of the Standard Industrial Classification system.
[b] Value of Shipments and Employment Size were supplied by the Bureau of the Census. See Appendix A.
*=Corresponding estimate in Detailed Statistics Tables is less than 0.5 rounded to zero.
W=Withheld to avoid disclosing data for individual companies. Data are included in higher level totals.
Q=Relative standard error greater than or equal to 50 percent.
Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846(S), "1985 Manufacturing Energy Consumption Survey: Part II–Fuel-Switching Capability."

Table B7. Relative Standard Errors for Table 7 of Detailed Statistics Section
(Percent)

Selected Characteristics		Coal and Coke			Alternative Types of Energy					
		Total Consumed	Switchable	Not Switchable	Purchased Electricity	Natural Gas	Distillate Fuel Oil	Residual Fuel Oil	LPG	Other
SIC Code[a] and Industries										
20	Food and Kindred Products	5	8	6	W	9	14	13	0	40
21	Tobacco Manufactures	8	8	W	0	W	W	W	0	0
22	Textile Mill Products	7	6	9	0	7	10	7	W	W
23	Apparel and Other Textile Products	21	36	29	0	40	36	0	0	0
24	Lumber and Wood Products	W	0	0	0	0	0	0	0	0
25	Furniture and Fixtures	15	17	20	0	0	0	W	W	43
26	Paper and Allied Products	5	8	6	13	8	24	7	24	23
2621	*Paper Mills, Except Building Paper*	5	6	6	13	9	11	7	0	14
2631	*Paperboard Mills*	10	11	16	37	14	22	15	45	36
27	Printing and Publishing	W	0	40	0	0	0	0	0	0
28	Chemicals and Allied Products	3	3	3	W	3	3	4	W	0
2819	*Industrial Inorganic Chemicals*	16	16	20	37	15	21	21	0	0
2821	*Plastics Materials and Resins*	5	7	7	0	10	10	W	W	0
2869	*Industrial Organic Chemicals*	W	5	5	W	5	6	W	W	0
2873	*Nitrogenous Fertilizers*	0	0	0	0	0	0	0	0	0
29	Petroleum and Coal Products	9	11	16	Q	15	13	11	23	0
2911	*Petroleum Refining*	9	11	16	0	15	14	11	W	0
30	Rubber and Misc. Plastics Products	W	12	11	0	22	W	W	0	0
31	Leather and Leather Products	33	Q	36	Q	0	Q	0	0	Q
32	Stone, Clay and Glass Products	5	5	9	Q	6	16	11	39	Q
3241	*Cement, Hydraulic*	W	5	9	0	6	17	11	0	Q
33	Primary Metal Industries	6	10	6	29	10	25	W	17	0
3312	*Blast Furnaces and Steel Mills*	6	10	6	0	11	W	W	W	0
3334	*Primary Aluminum*	0	0	0	0	0	0	0	0	0
34	Fabricated Metal Products	6	9	5	Q	9	W	W	W	0
35	Machinery, Except Electrical	5	5	6	0	6	7	11	W	0
36	Electric and Electronic Equipment	W	6	5	0	6	9	W	15	0
37	Transportation Equipment	4	6	5	W	7	11	W	W	0
38	Instruments and Related Products	W	W	W	W	0	0	W	0	0
39	Misc. Manufacturing Industries	17	W	Q	0	W	W	0	0	0
	Total	3	3	3	10	3	9	4	12	21
Census Region										
Northeast		8	5	11	15	9	7	5	W	0
Midwest		4	6	5	W	5	20	9	W	22
South		3	4	4	13	4	7	5	16	17
West		6	8	11	W	9	16	17	0	42
Total		3	3	3	10	3	9	4	12	21
Value of Shipments[b] (million dollars)										
Under 20		W	12	17	Q	13	26	22	41	Q
20-49		5	12	5	29	6	42	8	W	39
50-99		4	6	5	17	7	9	10	13	W
100-249		W	4	4	W	6	8	7	W	33
250-499		W	5	5	W	5	12	7	12	W
500 and Over		6	5	6	16	7	16	4	W	0
Total		3	3	3	10	3	9	4	12	21
Employment Size[b]										
Under 50		21	49	19	Q	49	Q	Q	Q	0
50-99		15	14	23	0	17	16	20	Q	Q
100-249		5	9	7	W	6	30	10	W	Q
250-499		4	5	5	W	6	9	10	W	31
500-999		4	6	6	16	8	13	9	16	45
1,000 and Over		4	4	4	13	5	8	4	9	15
Total		3	3	3	10	3	9	4	12	21

[a] See Appendices A and D for descriptions of the Standard Industrial Classification system.
[b] Value of Shipments and Employment Size were supplied by the Bureau of the Census. See Appendix A.
W=Withheld to avoid disclosing data for individual companies. Data are included in higher level totals.
Q=Relative standard error greater than or equal to 50 percent.
Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846(S), "1985 Manufacturing Energy Consumption Survey: Part II--Fuel-Switching Capability."

Appendix C

Fuel-Switching Survey Forms

Appendix C

Fuel-Switching Survey Forms

OMB No. 1905-0169: Approval Expires March 31, 1989

FORM **EIA-846(S)**
(11-4-86)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS
ACTING AS COLLECTING AND COMPILING AGENT FOR
UNITED STATES DEPARTMENT OF ENERGY
ENERGY INFORMATION ADMINISTRATION

1985 MANUFACTURING ENERGY CONSUMPTION SURVEY

PART II — FUEL SWITCHING CAPABILITY

NOTICE — Response to this inquiry **is required by law** (Federal Energy Administration Act of 1974, as amended, P.L. 93-275). By Section 9 of Title 13, U.S. Code, your report to the Census Bureau is confidential. It may be seen only by sworn Census Bureau employees and may be used only for statistical purposes. The law also provides that copies retained in your files are **immune from legal process.**

In correspondence pertaining to this report refer to this Census File Number (First 11 digits of top line)

Please copy the 11-digit Census File Number (CFN) from the mailing label

KEEP THIS COPY FOR YOUR FILES

PLEASE COMPLETE AND RETURN THE FORM WHICH SHOWS YOUR NAME AND ADDRESS

PLEASE COMPLETE THIS FORM AND RETURN TO

BUREAU OF THE CENSUS
1201 East Tenth Street
Jeffersonville, IN 47132

DUE DATE: December 31, 1986

If you cannot file by the due date, a time extension request should be sent to the above address. Please include your 11-digit Census File Number (CFN). Call (301) 763-7066 if you require any assistance with this form.

Please correct errors in name, address, and ZIP Code. ENTER street and number if not shown.

NOTE* – *Please read the enclosed instructions before filling out this form. See reverse side for examples.

CONTACT — This survey is a supplement to Form EIA-846(F) "1985 Manufacturing Energy Consumption Survey." The person given as this establishment's contact was –

Name

Telephone → Area code | Number | Extension

FUEL SWITCHING

(a) Line No	(b) Item		FUEL TYPE FROM THE EIA-846(F) 1985 MANUFACTURING ENERGY CONSUMPTION SURVEY (c) Purchased electricity	(d) Natural gas	(e) Distillate fuel oil (*No.'s 1, 2, and 4 fuel oils and diesel*)	(f) Residual fuel oil (*No.'s 5 and 6, navy special, and bunker C*)	(g) Coal and coke (*Anthracite, bituminous and subbituminous coal, lignite, coal coke, and breeze*)
			581 109	581 307	581 224	581 216	581 455
1	1985 fuel consumption data as reported on the EIA-846(F) "1985 Manufacturing Energy Consumption Survey."		582 1,000 kWh	582 1,000 cu. ft.	582 Barrels	582 Barrels	582 Short tons
	Answer lines 2 through 11 as appropriate. ***Do not consider differences in fuel prices when estimating amounts.***						
2	Enter the amount of the quantity on line 1 that could not have been replaced within 30 days by another fuel in 1985.		583 1,000 kWh	583 1,000 cu. ft.	583 Barrels	583 Barrels	583 Short tons
3	Subtract line 2 from line 1 and enter the results. This represents the substitutable portion of line 1.		584 1,000 kWh	584 1,000 cu. ft.	584 Barrels	584 Barrels	584 Short tons
4	Report the maximum amount of the quantity shown on line 3 that could have been switched to each of the replacement fuels listed to the right. Do not report switching capability that would have required more than 30 days to implement. *Do not consider differences in fuel prices when estimating amounts.*	Purchased electricity		585 1,000 cu. ft.	585 Barrels	585 Barrels	585 Short tons
5		Natural gas	586 1,000 kWh		586 Barrels	586 Barrels	586 Short tons
6		Distillate fuel oil	587 1,000 kWh	587 1,000 cu. ft.		587 Barrels	587 Short tons
7		Residual fuel oil	588 1,000 kWh	588 1,000 cu. ft.	588 Barrels		588 Short tons
8		Coal and coke	589 1,000 kWh	589 1,000 cu. ft.	589 Barrels	589 Barrels	
9		LPG	590 1,000 kWh	590 1,000 cu. ft.	590 Barrels	590 Barrels	590 Short tons
10		Other – *Specify*	591 1,000 kWh	591 1,000 cu. ft.	591 Barrels	591 Barrels	591 Short tons
	NOTE – *The sum of lines 4 through 10 should be at least as large as the amount on line 3, and may be larger.*						
11	Minimum lead time required to convert to your primary replacement fuel under the conditions described in the general instructions. If two or more replacement fuels have equivalent substitutability, select the one with the shortest lead time.		592 1 ☐ Less than 1 day 2 ☐ 1 day to 1 week 3 ☐ More than 1 week but within 30 days	592 1 ☐ Less than 1 day 2 ☐ 1 day to 1 week 3 ☐ More than 1 week but within 30 days	592 1 ☐ Less than 1 day 2 ☐ 1 day to 1 week 3 ☐ More than 1 week but within 30 days	592 1 ☐ Less than 1 day 2 ☐ 1 day to 1 week 3 ☐ More than 1 week but within 30 days	592 1 ☐ Less than 1 day 2 ☐ 1 day to 1 week 3 ☐ More than 1 week but within 30 days

COMMENTS — *Please use this space or attach a separate sheet for any explanations that may be essential in understanding your reported data.*

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CERTIFICATION — The data in this report are approximations, prepared in accordance with instructions.

Name of person to contact regarding this report — *Print or type* 542	543 Telephone: Area code	Number	Extension	**Period covered by this report** → FROM: Mo.	Day	Year	TO: Mo.	Day	Year
Address — *Number and street*				Signature of authorized person					
City	State	ZIP Code		Title			Date		

COMPLETION TIME — Enter the estimated number of hours spent completing this form. (Include time required to read the instructions, assemble any necessary information, and enter the data.) Hours: 544

EXAMPLES OF FUEL SWITCHING SITUATIONS

Example 1: Equipment Capability

The XYZ Manufacturing Plant consumed three energy sources as fuel in 1985: purchased electricity, natural gas, and residual fuel oil. The only use of natural gas and residual fuel oil was to fire, at an average 75 percent operating capacity, a gas/oil capable boiler where the switch in operating fuel could be made in a few hours. This boiler consumed 15 million cubic feet of natural gas (equivalent to 15 billion Btu) and 1,600 barrels of residual oil (equivalent to 10 billion Btu). Of the 6 million kWh of electricity, 5.3 million kWh was used for lighting and the running of machinery. The remaining 0.7 million kWh (equivalent to 2.5 billion Btu) was consumed in an electric boiler. This boiler was operated at an average 33 percent of its operating capacity, given the ongoing plant operation in 1985. However, the only times the electric boiler was actually in operation were during scattered peak periods when it supplemented the other boiler, and during times when the gas/oil boiler was down for maintenance or repairs. Altogether, the two boilers consumed 27.5 billion Btu of fuel during 1985, providing steam to the plant through a single piping system.

None of the 6 million kWh of electricity consumed is switchable because, (a) there were no alternate fuels for lighting and running machinery, and (b) the gas/oil boiler, even though it had unused capacity during 1985, could not have been "turned up" to produce the steam generated by the electric boiler at the times when the electric boiler was operating.

The 15 million cubic feet of natural gas that were consumed in the gas/oil boiler could have been totally replaced by residual fuel oil. The other substitution possibility involves burning one-third **less** natural gas in the gas/oil boiler, and running the electric boiler at full operating capacity. Under both of these alternatives, total fuel consumption would have remained at 27.5 billion Btu.

The fuel switching capability of the residual fuel oil is derived in the same manner. All of the residual oil could have been replaced by natural gas and half (800 barrels) could have been replaced by purchased electricity.

Example 2: Practical Limitations

Assume the same equipment configuration and fuel consumption as Example 1, with the following additional considerations:

(1) The XYZ plant has entered into a binding contract to purchase 600 barrels of residual fuel oil at a negotiated price;

(2) the gas/oil boiler is derated by 10 percent when oil is burned in place of natural gas;

(3) 1 million of the 15 million cubic feet of natural gas was burned during a 2 week period when oil supplies were interruped because of a strike by delivery personnel;

(4) the price for additional electricity above the 6 million kWh level is 3 cents per kWh higher than the price for the first 6 million.

As in Example 1, none of the 6 million kWh of electricity is switchable. The residual fuel oil contract prevents 600 barrels from being switched; however, the remaining 1,000 barrels is switchable. Eight hundred barrels can be replaced by increased use of the electric boiler as before. Any increased use of electricity beyond the 6 million kWh may have been economically inadvisable because of the increased price, but this is not a constraint to switching capability. All 1,000 switchable barrels can be replaced with natural gas.

Finally, the capability of switching from natural gas to electricity is the same as in Example 1. However, the capability to switch from gas to oil in the gas/oil boiler is reduced from 15 million to 14 million cubic feet to account for the period when residual fuel oil deliveries were interruped. All 14 million cubic feet can be switched by substituting residual fuel oil and running the boiler at a higher percentage of capacity to counteract the derating of the boiler.

Example 3: Exclusions to Fuel-Switching Capability

The ABC Manufacturing Plant consumed four energy sources during 1985: purchased electricity, natural gas, coal, and waste packaging materials. The 6 million kWh of electricity consumption were used only for lighting and the running of machinery. All natural gas consumption (2 million cubic feet) was in a series of paint drying ovens, which were also equipped to burn distillate fuel oil. However, distillate fuel oil was not used to fire the ovens because it could change the tint of the pigments in the paint, rendering the products unsaleable. Two boilers supplied the plant with heat and process steam through a single piping system. One boiler was a "garbage gulper," which was fired intermittently throughout the year as sufficient waste packaging materials became available. The total energy consumption of this boiler during 1985 was 5 billion Btu. The other boiler was capable of burning either coal or residual fuel oil and could be switched from one fuel to the other in three days. However, the only input to this boiler during 1985 was 5,000 tons of coal. For economic reasons, no residual fuel oil was burned.

None of the 6 million kWh of electricity consumption is switchable because there were no alternate fuels for lighting and the running of machinery. Even though distillate fuel oil could have been substituted for natural gas in the drying ovens, this would not be reported as switching capability because of the resulting changes in tint (i.e., consistent color is a requirement of the manufacturing process). Thus, none of the natural gas consumption is switchable.

The consumption of waste packaging materials could have been replaced by increasing the output of the coal/residual fuel oil boiler (if that boiler had unused capacity). However, we are not interested in this capability, and there is no place in the fuel switching table to record it.

Under the equipment configuration and plant operations as described at the beginning of this example, all of the coal consumption could have been replaced by residual fuel oil in the coal/oil boiler. On the other hand, none of the coal could have been replaced by waste packaging materials, because the "garbage gulper" was being used to the maximum possible extent, given the plant operations during 1985. However, the definition of switching capability does allow a respondent some latitude in determining switching capability in these circumstances. This latitude is based upon the respondent's understanding of the availability of alternate fuels and the condition of energy-using equipment during 1985. If the respondent for the ABC Manufacturing Plant knew that residual fuel oil was not available to the plant during 1985, switching capability from coal to residual fuel oil should be recorded as zero, regardless of the capability of the equipment to accept residual fuel oil. Conversely, fuel switching from coal to waste materials could be nonzero if the respondent knew of additional supplies of waste that could have been hauled in and used to fuel the "garbage gulper" in an emergency.

EIA-846(S)-I
(11-4-86)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS
ACTING AS COLLECTING AND COMPILING AGENT FOR
UNITED STATES DEPARTMENT OF ENERGY
ENERGY INFORMATION ADMINISTRATION

INSTRUCTIONS FOR FORM EIA-846(S)

1985 MANUFACTURING ENERGY CONSUMPTION SURVEY

PART II — FUEL SWITCHING CAPABILITY

GENERAL INSTRUCTIONS

PURPOSE — This survey is a supplement to the EIA-846(F) "1985 Manufacturing Energy Consumption Survey." It is intended to measure the short-term (within 30 days) capability of your establishment to have used substitute fuels in place of those actually consumed in 1985.

- For purposes of this survey, capability to use substitute fuels means that this establishment's combustors (e.g., boilers, furnaces, ovens, blast furnaces) had the machinery or equipment in place (or available for installation) in 1985 so that fuel substitutions could actually have been introduced within 30 days, without extensive modifications.

- This survey is designed to collect information on your establishment's fuel switching capability in 1985. Capability is not determined by the relative prices of fuels; it depends only on the characteristics of your equipment and certain legal constraints. Fuel switching capability sets limits on the extent to which you could switch to a substitute fuel if you wanted to or needed to. It has **nothing** to do with whether you **would** switch if you could. THEREFORE, RELATIVE PRICES OF FUELS ARE NOT RELATED TO FUEL SWITCHING CAPABILITY AND SHOULD BE IGNORED WHEN COMPLETING THIS QUESTIONNAIRE.

- Base your approximations of fuel switching capability on your best recollection of the availability of substitute fuels and the physical condition of your equipment during 1985.

- Include switching capability that resulted from the use of redundant and/or standby combustors, and from combustors that were already equipped to fire alternative fuels.

- We recognize that records of fuel switching capability are not regularly maintained. Accordingly, reasonable approximations of fuel switching capability are acceptable for this survey. These approximations should be based on the judgement of a person knowledgeable about the fuel switching capability and operations of your establishment. They are not expected to be formal engineering estimates based on a day-by-day analysis of the operating levels of individual combustors and interactions between them. However, please try to respond as realistically as possible, given your actual operations in 1985.

SPECIFIC INSTRUCTIONS

FUEL SWITCHING

Line 1 — *The fuel consumption numbers reported on form* EIA-846(F) have been preprinted on line 1 to assist you in completing this form. If any of these numbers are incorrect please line through the incorrect number and enter the correct figure above it.

Line 2 — Report the amount of the quantity preprinted in line 1 that could NOT have been replaced within 30 days by another fuel in 1985, even given a severe curtailment. Amounts may be nonswitchable due to limitations such as the following:

- The characteristics of your physical plant (e.g., single-fired combustors or the absence of redundant and/or standby combustors), or the requirements of your manufacturing process, limit switching.

- Binding fuel contracts are in place that limit your ability to switch fuels.

- Environmental regulations limit the amounts of potential replacement fuels that could be burned.

Line 3 — Subtract line 2 from line 1 and enter the results. These values represent the quantities of fuels actually burned that COULD HAVE BEEN REPLACED within 30 days by another fuel in 1985.

Lines 4 through 10 — Report the maximum amount of the quantity shown on line 3 that could have been replaced within 30 days by each of the fuels on lines 4 through 10, UNDER THE CONSTRAINTS LISTED IN THE INSTRUCTIONS FOR LINE 2.

Line 11 — Mark the minimum lead time required to convert to the primary replacement fuel. If two or more replacement fuels have equivalent substitutability, select the one with the shortest lead time.

Definitions: kWh — Kilowatthour
LPG — ethane, ethylene, propane, propylene, butane, isobutane, butylene, and mixtures
Barrels — 42 gallons
mcf — 1,000 cubic feet (10 ccf)

BTU conversion factors: If you need Btu conversions to approximate fuel switching capability, the values in the following table should be used. The resulting fuel switching approximations are to be reported in the units specified in the questionnaire, however.

Electricity	1 kWh = 3,412 Btu
Natural gas	1 cubic foot = 1,000 Btu
Distillate fuel oil	1 barrel = 5.8 million Btu
Residual fuel oil	1 barrel = 6.3 million Btu
Coal and coke	1 short ton = 23 million Btu

COMMENTS

Please provide any explanations that may be essential in understanding your reported data. Attach a separate sheet if necessary.

CERTIFICATION

Period covered by this report — Enter the month and day of the beginning and the end of the period your report covers. If a calendar year report: "From January 1 to December 31, 1985," if a fiscal year, specify which (such as "From December 1, 1984, to November 30, 1985)." If a part-year report is submitted because the establishment was not in operation or under your company's control for the entire year, specify the actual period covered: For example, "January 1, 1985 to August 15, 1985," or "June 1, 1985 to December 31, 1985."

If you need further information to help in interpreting these instructions, see reverse side of report form for examples of fuel switching situations.

Call (301) 763-7066 if you require any assistance in completing the form.

Appendix D

Descriptions of Industry Groups and Selected Industries

Appendix D

Descriptions of Industry Groups and Selected Industries

This appendix contains descriptions of industrial groups and selected industries taken from the SIC Manual,[8] 1972. That manual was complied by the Office of Management and Budget's Statistical Policy Division. The 20 major industrial groups and the 10 selected industries in this appendix, comprise the 30 strata of the MECS. (The manufacturing establishment and the SIC system were generally described in Appendix A.)

SIC 20--Food and Kindred Products

This major group includes establishments manufacturing or processing foods and beverages for human consumption, and certain related products, such as manufactured ice, chewing gum, vegetable and animal fats and oils, and prepared feeds for animals and fowls.

SIC 21--Tobacco Manufactures

This major group includes establishments engaged in manufacturing cigarettes, cigars, smoking and chewing tobacco, and snuff, and in stemming and redrying tobacco.

SIC 22--Textile Mill Products

This major group includes establishments engaged in performing any of the following operations: (1) preparation of fiber and subsequent manufacturing of yarn, thread, braids, twine, and cordage; (2) manufacturing broad woven fabric, narrow woven fabric, knit fabric, and carpets and rugs from yarn; (3) dyeing and finishing fiber, yarn, fabric, and knit apparel; (4) coating, waterproofing, or otherwise treating fabric; (5) the integrated manufacture of knit apparel and other finished articles from yarn; and (6) the manufacture of felt goods, lace goods, nonwoven fabrics, and miscellaneous textiles.

SIC 23--Apparel

The major group, known as the cutting-up and needle trades, includes establishments producing clothing and fabricating products by cutting and sewing purchased woven or knit textile fabrics and related materials such as leather, rubberized fabrics, plastics, and furs.

SIC 24--Lumber and Wood Products, Except Furniture

This major group includes logging camps engaged in cutting timber and pulpwood; merchant sawmills, lath mills, shingle mills, cooperage stock mills, planing mills, and plywood mills and veneer mills engaged in producing lumber and wood basic materials; and establishments engaged in manufacturing finished articles made entirely or mainly of wood or wood substitutes.

SIC 25--Furniture and Fixtures

This major group includes establishments engaged in manufacturing household, office, public building, and restaurant furniture; and office and store fixtures.

SIC 26--Paper and Allied Products

This major group includes the manufacture of pulps from wood and other cellulose fibers, and from rags; the manufacture of paper and paperboard; and the manufacture of paper and paperboard into converted products such as paper coated off the paper machine, paper bags, paper boxes and envelopes.

2621--Paper Mill, Except Building Paper Mills. Establishments primarily engaged in manufacturing paper from wood pulp and other fibers, and which may also manufacture converted paper products.

[8]Office of Management and Budget, *Standard Industrial Classification Manual,* pp. 59-211.

2631--Paperboard Mills. Establishments primarily engaged in manufacturing paperboard, including paperboard coated on the paperboard machine, from wood pulp and other fibers; and which may also manufacture converted paperboard products.

SIC 27--Printing and Publishing, and Allied Industries

This major group includes establishments engaged in printing by one or more of the common processes, such as letterpress, lithography, gravure, or screen; and those establishments which perform services for the printing trade, such as bookbinding, typesetting, engraving, photoengraving, and electrotyping. This major group also includes establishments engaged in publishing newspapers, books, and periodicals, regardless of whether or not they do their own printing.

SIC 28--Chemicals and Allied Products

This major group includes establishments producing basic chemicals, and establishments manufacturing products by predominantly chemical processes. Establishments classified in this major group manufacture three general classes of products: (1) basic chemicals such as acids, alkalies, salts, and organic chemicals; (2) chemical products to be used in further manufacture such as synthetic fibers, plastics materials, dry colors, and pigments; (3) finished chemical products to be used for ultimate consumption such as drugs, cosmetics, and soaps; or to be used as materials or supplies in other industries such as paints, fertilizers, and explosives.

2819--Industrial Inorganic Chemicals, Not Elsewhere Classified. Establishments primarily engaged in manufacturing industrial inorganic chemicals, not elsewhere classified. Important products of this industry include inorganic salts of sodium (excluding refined sodium chloride), potassium, aluminum, calcium, chromium, magnesium, mercury, nickel, silver, tin; inorganic compounds such as alums, calcium carbide, hydrogen peroxide, sodium silicate, ammonia compounds (except fertilizers), rare earth metal salts and elemental bromine, fluorine, iodine, phosphorus, and alkali metals (sodium, potassium, lithium, etc.).

2821--Plastics, Synthetic Resins, and Nonvulcanizable Elastomers. Establishments primarily engaged in manufacturing synthetic resins, plastics materials and nonvulcanizable elastomers. Important products of this industry include: cellulose plastic materials; phenolic and other tar acid resins; urea and melamine resins; vinyl resins; styrene resins; alkyd resins; acrylic resins; polyethylene resins; polypropylene resins; rosin modified resins; coumarone-indene and petroleum polymer resins; and miscellaneous resins including polyamide resins, silicones, polyisobutylenes, polyesters, polycarbonate resins, acetal resins, fluorohydrocarbon resins; and casein plastics.

2869--Industrial Organic Chemicals, Not Elsewhere Classified. Establishments primarily engaged in manufacturing industrial organic chemicals, not elsewhere classified. Important products of this industry include: noncyclic organic chemicals; solvents; polyhydric alcohols; synthetic perfume and flavoring materials; rubber processing chemicals; plasticizers; synthetic tanning agents; chemical warfare gases; and esters, amines, etc., of polyhydric alcohols and fatty and other acids.

2873--Nitrogenous Fertilizers. Establishments primarily engaged in manufacturing nitrogenous fertilizer materials or mixed fertilizers from nitrogenous materials produced in the same establishment.

SIC 29--Petroleum Refining and Related Industries

This major group includes establishments primarily engaged in petroleum refining, manufacturing paving and roofing materials, and compounding lubricating oils and greases from purchased materials.

2911--Petroleum Refining. Establishments primarily engaged in manufacturing industrial distillate fuel oils, residual fuel oils, lubricants, and other products from crude petroleum and its fractionation products, through straight distillation of crude oil, redistillation of unfinished petroleum derivatives, cracking or other processes.

SIC 30--Rubber and Miscellaneous Plastics Products

This major group includes establishments manufacturing rubber products such as tires, rubber footwear, mechanical rubber goods, heels and soles, flooring, and rubber sundries.

SIC 31--Leather and Leather Products

This major group includes establishments engaged in tanning, currying, and finishing hides and skins, and establishments manufacturing finished leather and artificial leather products and some similar products made of other materials. Leather converters are also included.

SIC 32--Stone, Clay, Glass, and Concrete Products

This major group includes establishments engaged in manufacturing flat glass and other glass products, cement, structural clay products, pottery, concrete and gypsum products, cut stone, abrasive and asbestos products, etc., from materials taken principally from the earth in the form of stone, clay, and sand.

3241--Cement, Hydraulic. Establishments primarily engaged in manufacturing hydraulic cement, including portland, natural, masonry, and pozzolan cements.

SIC 33--Primary Metal Industries

This major group includes establishments engaged in the smelting and refining of ferrous and nonferrous metals from ore, pig, or scrap; in the rolling, drawing, and alloying of ferrous and nonferrous metals; in the manufacture of castings and other basic products of ferrous and nonferrous metals; and in the manufacture of nails, spikes, and insulated wire and cable. This major group also includes the production of coke.

3312--Blast Furnace (Including Coke Ovens), Steel Works, and Rolling Mills. Establishments primarily engaged in manufacturing hot metal, pig iron, silvery pig iron, and ferroalloys from iron ore and iron and steel scrap; converting pig iron, scrap iron and scrap steel into steel; and in hot rolling iron and steel into basic shapes such as plates, sheets, strips, rods, bars, and tubing.

3334--Primary Production of Aluminum. Establishments primarily engaged in producing aluminun from alumina, and in refining aluminum by any process.

SIC 34--Fabricated Metal Products, Except Machinery and Transportation Equipment

This major group includes establishments engaged in fabricating ferrous and nonferrous metal products such as metal cans, tinware, hand tools, cutlery, general hardware, nonelectric heating apparatus, fabricated structural metal products, metal forgings, metal stampings, ordnance (except vehicles and guided missiles), and a variety of metal and wire products not elsewhere classified.

SIC 35--Machinery, Except Electrical

This major group includes establishments manufacturing machinery and equipment, other than electrical equipment and transportation equipment.

SIC 36--Electrical and Electronic Machinery, Equipment, and Supplies

This major group includes establishments manufacturing machinery, apparatus, and supplies for the generation, storage, transmission, transformation, and utilization of electrical energy. The manufacture of household appliances is included in this group, but industrial machinery and equipment powered by built-in or detachable electric motors are classified in Major Group 35.

SIC 37--Transportation Equipment

This major group includes establishments engaged in manufacturing equipment for transportation of passengers and cargo by land, air, and water. Important products produced by establishments classified in this major group include motor vehicles, aircraft, guided missiles and space vehicles, ships, boats, railroad equipment, and miscellaneous transportation equipment such as motorcycles, bicycles, and snowmobiles.

SIC 38--Instruments and Related Products

This major group includes establishments engaged in manufacturing instruments (including professional and scientific) for measuring, testing, analyzing, and controlling, and their associated sensors and accessories; optical instruments and lenses; surveying and drafting instruments; surgical, medical, and dental instruments, equipment, and supplies; ophthalmic goods; photographic equipment and supplies; and watches and clocks.

SIC 39--Miscellaneous Manufacturing Industries

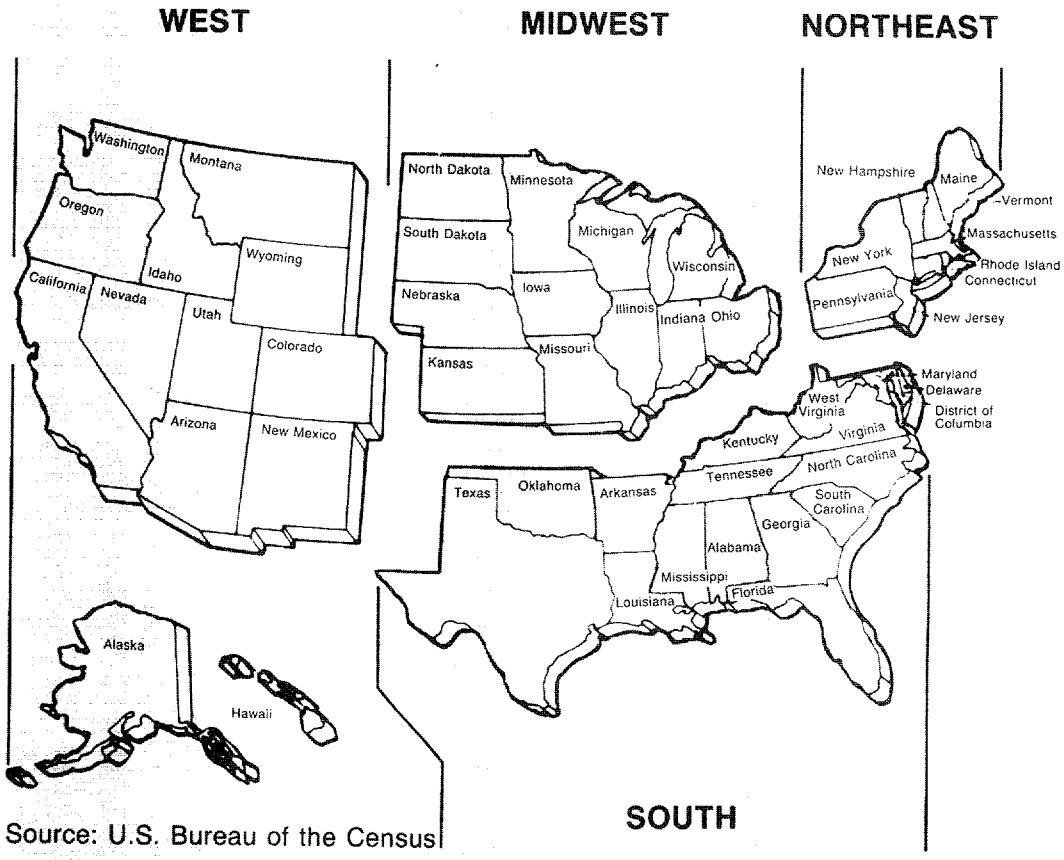
This major group includes establishments primarily engaged in manufacturing products not classified in any other manufacturing major group. Industries in this group fall into the following categories: jewelry, silverware and plated ware; musical instruments; toys, sporting and athletic goods; pens, pencils, and other office and artists' materials; buttons, costume novelties, miscellaneous notions; brooms and brushes; caskets; and other miscellaneous manufacturing industries.

Appendix E

Map of U.S. Census Regions

Appendix E

Map of U.S. Census Regions



Source: U.S. Bureau of the Census

Appendix F

Related Publications on Energy Consumption

Appendix F

Related Publications on Energy Consumption

See inside front cover for information concerning copies of these publications.

Industrial Sector

Manufacturing Energy Consumption Survey: Methodological Report, 1985; 1988.

Manufacturing Energy Consumption Survey: Consumption of Energy, 1985; 1988.

"Manufacturing Sector Energy Consumption, 1985 Provisional Estimates," *Monthly Energy Review,* January 1987, DOE/EIA-0035(87/01), pp. vii-x.

Report on the 1980 Manufacturing Industries' Energy Consumption Study and Survey of Large Combustors; February 1983, DOE/EIA-0358, GPO Stock No. 061-003-00293-5.

Industrial Energy Consumption, "Survey of Large Combustors: Report on Alternate Fuel-Burning Capabilities of Large Boilers in 1979" ; February 1982, DOE/EIA-0304, GPO Stock No. 061-003-0233-1.

Methodological Report of the 1980 Manufacturing Industries Survey of Large Combustors (EIA-463); March 1982, DOE/EIA-0306 (no GPO Stock No.).

Commercial Sector

Characteristics of Buildings

Nonresidential Buildings Energy Consumption Survey: Characteristics of Commercial Buildings, 1983; July 1985, DOE/EIA-0246(83), GPO Stock No. 061-003-00439-3.

Nonresidential Buildings Energy Consumption Survey: Characteristics of Commercial Buildings, 1983; A Supplemental Reference, DOE/EIA-M008. Available from the National Technical Information Service (NTIS), Order Number DE-85015581.

Nonresidential Buildings Energy Consumption Survey: Fuel Characteristics and Conservation Practices; June 1981, DOE/EIA-0278, GPO Stock No. 061-003-00200-5.

Nonresidential Buildings Energy Consumption Survey: Building Characteristics; March 1981, DOE/EIA-0246, GPO Stock No. 061-003-00171-8.

Consumption and Expenditures

Nonresidential Building Energy Consumption Survey: Commercial Buildings Consumption and Expenditures, 1983; September 1986, DOE/EIA-0318(83), GPO Stock No. 061-003-00496-2.

Nonresidential Buildings Energy Consumption Survey: 1979 Consumption and Expenditures, Part 1: Natural Gas and Electricity; March 1983, DOE/EIA-0318/1, GPO Stock No. 061-003-00298-6.

Nonresidential Buildings Energy Consumption Survey: 1979 Consumption and Expenditures, Part 2: Steam, Coal, Fuel Oil, LPG, and Total Fuels; December 1983, DOE/EIA-0318(79)/2, GPO Stock No. 061-003-00366-4.

Residential Sector

Housing Characteristics

Residential Energy Consumption Survey: Housing Characteristics 1984; September 1986, DOE/EIA-0314(84), GPO Stock No. 061-003-00499-7.

Residential Energy Consumption Survey: Housing Characteristics, 1982; August 1984, DOE/EIA-0314(82), GPO Stock No. 061-003-00393-1.

Residential Energy Consumption Survey: Housing Characteristics, 1981; August 1983, DOE/EIA-0314(81), GPO Stock No. 061-003-00330-3.

Residential Energy Consumption Survey: Housing Characteristics, 1980; June 1982, DOE/EIA-0314, GPO Stock No. 061-003-00256-1.

Residential Energy Consumption Survey: Characteristics of the Housing Stock and Households, 1978; February 1980, DOE/EIA-0207/2, GPO Stock No. 061-003-00093-2.

Residential Energy Consumption Survey: Conservation; February 1980, DOE/EIA-0207/3, GPO Stock No. 061-003-00087-8.

Preliminary Conservation Tables from the National Interim Energy Consumption Survey; August 1979, DOE/EIA-0193/P (no GPO Stock No.).

Characteristics of the Housing Stock and Households: Preliminary Findings from the National Interim Energy Consumption Survey; October 1979, DOE/EIA-0199/P (no GPO Stock No.).

Consumption and Expenditures

Residential Energy Consumption Survey: Consumption and Expenditures, April 1984 through March 1985 Part 1: National Data; March 1987, DOE/EIA-0321(84), GPO Stock No. 061-003-00519-5.

Residential Energy Consumption Survey: Consumption and Expenditures, April 1984 through March 1985 Part 2: Regional Data; May 1987, DOE/EIA-0321/2(84), GPO Stock No. 061-003-00528-4.

Residential Energy Consumption Survey: Consumption and Expenditures, April 1982 Through March 1983, Part 1: National Data ; November 1984, DOE/EIA-0321/1(82), GPO Stock No. 061-003-00411-3.

Residential Energy Consumption Survey: Consumption and Expenditures, April 1982 Through March 1983, Part 2: Regional Data ; December 1984, DOE/EIA-0321/2(82), GPO Stock No. 061-003-00414-8.

Residential Energy Consumption Survey: Consumption and Expenditures, April 1981 Through March 1982, Part 1: National Data ; September 1983, DOE/EIA-0321/1(81), GPO Stock No. 061-003-00340-1.

Residential Energy Consumption Survey: Consumption and Expenditures, April 1981 Through March 1982, Part 2: Regional Data ; October 1983, DOE/EIA-0321/2(81), GPO Stock No. 061-003-00357-5.

Residential Energy Consumption Survey: Consumption and Expenditures, April 1980 Through March 1981, Part 1: National Data ; September 1982, DOE/EIA-0321/1(80), GPO Stock No. 061-003-00278-1.

Residential Energy Consumption Survey: Consumption and Expenditures, April 1980 Through March 1981, Part 2: Regional Data ; June 1983, DOE/EIA-0321/2(80), GPO Stock No. 061-003-00319-2.

Residential Energy Consumption Survey: 1979-1980 Consumption and Expenditures, Part 1: National Data (Excluding Conservation); April 1981, DOE/EIA-0262/1, GPO Stock No. 061-003-00191-2.

Residential Energy Consumption Survey: 1979-1980 Consumption and Expenditures, Part 2: Regional Data; May 1981, DOE/EIA-0262/2, GPO Stock No. 061-003-00189-1.

Residential Energy Consumption Survey: Consumption and Expenditures, April 1978 Through March 1979; July 1980, DOE/EIA-0207/5, GPO Stock No. 061-003-00131-9.

Single-Family Households: Fuel Oil Inventories and Expenditures: National Interim Energy Consumption Survey; December 1979, DOE/EIA-0207/1, GPO Stock No. 061-003-00075-4.

Other Publications on the Residential Sector

"End-Use Consumption of Residential Energy," *Monthly Energy Review,* July 1987, DOE/EIA-0035(87/07), pp. vii-xiv.

Residential Energy Consumption Survey: Trends in Consumption and Expenditures, 1978-1984; June 1987, DOE/EIA-0482, GPO Stock No. 061-003-00537-7.

Residential Conservation Measures; July 1986, SR/EEUD/86/01 (no GPO Stock No.).

An Economic Evaluation of Energy Conservation and Renewable Energy Tax Credits; October 1985, Service Report (no GPO Stock No.).

Residential Energy Consumption and Expenditures by End Use for 1978, 1980, and 1981; December 1984, DOE/EIA-0458, GPO Stock No. 061-003-00415-6.

Weatherization Program Evaluation, SR-EEUD-84-1; August 1984 (available from the Office of the Assistant Secretary for Conservation and Renewable Energy, Department of Energy).

Residential Energy Consumption Survey: Regression Analysis of Energy Consumption by End Use; October 1983, DOE/EIA-0431, GPO Stock No. 061-003-00347-8.

National Interim Energy Consumption Survey: Exploring the Variability In Energy Consumption; July 1981, DOE/EIA-0272, GPO Stock No. 061-003-00205-6.

National Interim Energy Consumption Survey: Exploring the Variability in Energy Consumption--A Supplement; October 1981, DOE/EIA-0272/S, GPO Stock No. 061-003-00217-0.

Energy Use by U.S. Households; November 1980, DOE/EIA-0248 (brochure, no GPO Stock No.).

Residential Transportation Sector

Residential Transportation Energy Consumption Survey: Consumption Patterns of Household Vehicles 1985; April 1987, DOE/EIA-0464(85), GPO Stock No. 061-003-00521-7.

Residential Transportation Energy Consumption Survey: Consumption Patterns of Household Vehicles, 1983; January 1985, DOE/EIA/0464(83), GPO Stock No. 061-003-00420-2.

Residential Energy Consumption Survey: Consumption Patterns of Household Vehicles, Supplement: January 1981 to September 1981; February 1983, DOE/EIA-0328, GPO Stock No. 061-003-00297-8.

Residential Energy Consumption Survey: Consumption Patterns of Household Vehicles, June 1979 to December 1980; April 1982, DOE/EIA-0319 (no GPO Stock No.).

Cross-Sector

Natural Gas: Use and Expenditures; April 1983, DOE/EIA-0382, GPO Stock No. 061-003-00307-9.

Planned Publications for 1989

Manufacturing Energy Consumption Survey: Energy Efficiency In Manufacturing, 1985.

Nonresidential Buildings Energy Consumption Survey: Commercial Buildings Consumption and Expenditures, 1986.

Residential Energy Consumption Survey: Housing Characteristics, 1987.

Residential Energy Consumption Survey: Consumption and Expenditures, January 1987 Through December 1987, Part 1: National Data.

Residential Energy Consumption Survey: Consumption and Expenditures, January 1987 Through December 1987, Part 2: Regional Data.

Residential Transportation Energy Consumption Survey: Consumption Patterns of Household Vehicles, 1988.

Glossary

Anthracite: A hard, black, lustrous coal containing a high percentage of fixed carbon and a low percentage of volatile matter. It is often referred to as hard coal. For purposes of the Manufacturing Energy Consumption Survey (MECS), anthracite contains approximately 23.031 million Btu per short ton.

Barrel: A volumetric unit of measure equivalent to 42 U.S. gallons.

Biomass: Organic (animal waste), nonfossil plant material constituting an exploitable energy resource.

Bituminous Coal: A soft coal (the most common solid fossil fuel), is high in carbonaceous matter, with a volatility greater than anthracite and a calorific value greater than lignite. For purposes of the MECS, bituminous coal used as a fuel contains approximately 22.012 million Btu per short ton; bituminous coal used for coking, contains approximately 26.8 million Btu per short ton.

Blast Furnace: A shaft furnace in which solid fuel is burned with an air blast to smelt ore in a continuous operation.

Blast Furnace Gas: Waste combustible gas generated in a blast furnace when iron ore is being reduced with coke to metallic iron. It is commonly used as a fuel within the steel works.

Breeze: The residue from the fine screenings of crushed coke.

British Thermal Unit (Btu): The amount of energy required to raise the temperature of 1 pound of water 1 degree Fahrenheit at or near 39.2 °F.

Butane (C_4H_{10}): A normally gaseous, paraffinic hydrocarbon extracted from natural gas or refinery gas streams. It includes isobutane (a branch-chain configuration) and normal butane (a straight-chain configuration). It is used primarily for blending into high-octane gasoline, for residential and commercial heating, and for industrial uses, especially the manufacture of chemicals and synthetic rubber.

Butylene (C_4H_8): A normally gaseous, olefinic hydrocarbon recovered from the refinery processes, and converted to alkylate, a high-octane gasoline blending component.

Byproduct: A secondary or additional product resulting from the feedstock use of energy or processing of nonenergy materials. For example, the more common byproducts of coke ovens are coal gas, tar, and a mixture of benzene, toluene, and xylenes (BTX).

Census Region: A geographic area defined by the Bureau of Census, consisting of various States selected according to population size and physical location. The States are grouped into four regions:

1. Northeast: Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont
2. South: Alabama, Arkansas, Delaware, the District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia
3. Midwest: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin
4. West: Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming

Coal Coke: The strong, porous residue, consisting of carbon and mineral ash, that is formed when the volatile constituents of bituminous coal are driven off by heat in the absence of or with a limited supply of air. Coal Coke is used primarily in blast furnaces.

Cogeneration: The production of electrical energy and another form of useful energy (such as heat or steam) through the sequential use of energy.

Coke Oven Gas: The mixture of permanent gases produced by the carbonization of coal in a coke oven at temperatures in excess of 1000 ^{o}C.

Company (Firm): As used in the MECS, a company is an economic entity consisting of one or more physical locations, at least one of which is involved in manufacturing. If the company consists of a single physical location, the term is synonymous with manufacturing establishment. (See Manufacturing Establishment.)

Consumption: The use of energy as a source of heat or power, or as an input in the manufacturing process.

Conversion Factor: A number which translates units of one system into corresponding values of another system. Conversion factors are used to translate physical units of measures for various fuels into Btu equivalents.

Crude Oil: A mixture of hydrocarbons that exists in a liquid state in natural underground reservoirs and remains liquid at atmospheric pressure after passing through surface separating facilities. Crude oil includes liquids technically defined as crude oil and small amounts of nonhydrocarbons produced with the oil, as well as small amounts of hydrocarbons that exist in the gaseous phase in natural underground reservoirs, but are liquid at atmospheric pressure after being recovered from oil well (casinghead) gas in lease separators. Crude oil is reported as liquid equivalents at the surface (excluding basic sediment and water), measured in terms of stock tank barrels of 42 U.S. gallons at atmospheric pressure, and corrected to 60 ^{o}F.

Cubic Foot: The amount of gas contained in a cube with an edge that is 1-foot long.

Distillate Fuel Oil: A general classification for light fuel oils distilled during the refining process. Includes products known as Nos. 1, 2, and 4 fuel oils; and Nos. 1, 2, and 4 diesel fuels. It is used primarily for space heating, on-and-off-highway engine fuel, and electric power generation.

Energy: The capacity for doing work as measured by the capability of doing work (potential energy) or the conversion of this capability to motion (kinetic energy).

Establishment: As defined by the *1972 Standard Industrial Classification Manual,* ". . . an economic unit, generally at a single physical location where business is conducted or where services or industrial operations are performed."

Ethane (C_2H_6): A colorless, odorless, gaseous hydrocarbon extracted from natural gas or refinery gas streams. Ethane is used primarily as petrochemical feedstock for production of chemicals and plastic materials.

Ethylene (C_2H_4): A colorless, flammable, gaseous, olefinic hydrocarbon recovered from natural gas and petroleum. Ethylene is used primarily as a petrochemical feedstock for numerous chemical applications and the production of consumer goods.

Expenditures: Funds spent for energy purchased and paid for, or delivered to a manufacturer during the 365-day period of calendar year 1985. For purposes of the MECS, the expenditure dollar amount includes State and local taxes and delivery charges.

Fossil Fuel: Any naturally occurring organic fuel, such as coal, crude oil, and natural gas.

Fuel: Any substance that can be burned to produce heat.

Fuel Use (of Energy): Use of energy in the production of heat, steam, power, or the generation of electricity.

Generation: The process of producing steam or electrical energy by transforming other forms of energy.

Geothermal Energy: Hot water or steam, extracted from reservoirs in the earth's crust, which is generally supplied to steam turbines that drive generators to produce electricity.

Hydroelectric Power: Electricity generated by a turbine driven by falling water.

Hydrogen: A colorless, odorless, highly flammable, gaseous element; the lightest of all gases and the most abundant element in the universe.

Kilowatthour (kWh): A unit of work or energy, measured as 1,000 watts (1 kilowatt) of power expended for 1 hour. Once generated, 1 kWh is equivalent to 3,412 Btu.

Liquefied Petroleum Gases (LPG): Ethane, ethylene, propane, propylene, normal butane, butylene, ethane-propane mixtures, propane-butane mixtures, and isobutane produced at refineries or natural gas processing plants, including plants that fractionate raw natural gas plant liquids.

Lease Condensate: A natural gas liquid recovered from gas well gas (associated and nonassociated) in lease separators or field facilities. Lease condensate consists primarily of pentanes and heavier hydrocarbons. Volumes are reported in terms of barrels of 42 U.S. gallons, at atmospheric pressure, and corrected to 60 °F.

Lease Separator: A facility located at the surface for the purpose of (1) separating casinghead gas from produced crude oil and water at the temperature and pressure conditions of the separator; and (2) separating gas from that portion of associated gas and nonassociated gas which liquefies at temperature and pressure conditions of the separator.

Lignite: A brownish-black coal of low rank with a high percentage of inherent moisture and volatile matter content. It is also referred to as brown coal. For purposes of MECS, lignite contains approximately 22.012 million Btu per short ton.

Manufacturing Establishment: An economic unit at a single physical location where the mechanical or chemical transformation of materials or substances into new products is performed. These operations are generally conducted in facilities described as plants, factories, or mills and characteristically use power-driven machines and material-handling equipment. In addition, the assembly of components of manufactured products is considered manufacturing, as is the blending of materials such as lubricating oil, plastics, resins, or liquors.

Manufacturing Sector: The universe of manufacturing establishments within the 50 States and the District of Columbia. (See Standard Industrial Classification.)

Megawatthours (MWh): A unit of work of energy, measured as 1 million watts (1 megawatt) of power expended for 1 hour.

Motor Gasoline: A complex mixture of relatively volatile hydrocarbons, with or without small quantities of additives, obtained by blending appropriate refinery streams to form a fuel suitable for use in spark-ignition engines. Motor gasoline includes both leaded and unleaded grades of finished motor gasoline, blending components, and gasohol.

Natural Gas: A mixture of hydrocarbon compounds and small quantities of various nonhydrocarbons existing in the gaseous phase or in solution with oil in natural underground reservoirs at reservoir conditions. Natural gas may be subclassified as:

1. Associated Gas: Free natural gas, commonly known as gas-cap gas, which overlies and is in contact with crude oil in the reservoir.
2. Dissolved Gas: Natural gas which is in solution with crude oil in the reservoir at reservoir conditions.
3. Nonassociated Gas: Free natural gas not in contact with crude oil in the reservoir.

All natural gas volumes are reported in cubic feet at a pressure base of 14.73 psia, at 60 °F. For the purposes of the MECS, natural gas contains 1,032 Btu per cubic foot.

Nonfuel Use (of Energy): Use of energy as feedstock (for example, coal used to produce coke, crude oil used to produce petroleum products), raw materials, additives, or ingredients for products manufactured, or for any other purpose besides fuel use.

Petroleum Coke: A solid residue, high in carbon content and low in hydrogen, which is the final product of thermal decomposition in the condensation process in cracking crude oil. Petroleum coke can yield almost pure carbon or artificial graphite suitable for production of carbon or graphite electrodes, structural graphite, motor brushes, dry cells, and similar products. For the purposes of the MECS, petroleum coke contains approximately 6.024 million Btu per barrel.

Petrochemical Feedstock: Chemical feedstocks derived from petroleum, and used principally for the manufacture of chemicals, synthetic rubber, and a variety of plastics.

Plant: Commonly used as a synonym for establishment. However, the term can also be used to refer to a particular process within an establishment.

Propane (C_3H_8): A colorless, gaseous hydocarbon extracted from natural gas or refinery gas streams. It is used primarily for residential and commercial heating and cooling, and also as a fuel for transportation. Industrial applications include use as a petrochemical feedstock.

Propylene (C_3H_6): A gaseous hydrocarbon recovered from refinery processes. Propylene is used primarily as a petrochemical feedstock.

Pulping Liquor (Black Liquor): The alkaline spent liquor removed from the digesters in the process of chemically pulping wood. After evaporation, the liquor is burned as fuel in a furnace that permits the recovery of certain reusable chemicals.

Quadrillion Btu (Quad): Equivalent to 10^{15} Btu.

Refinery: A plant, device, or process which heats crude oil so that it separates into chemical components, which are then distilled off as more usable substances. Simple structure components vaporize first. Typical crude fractions are unstabilized gas, naphtha, kerosene and diesel range middle distillates, atmospheric gas oil, and atmospheric residual.

Relative Standard Error (RSE): A measure of the reliability or precision of a survey statistic. Relative Standard Error, or RSE, is a measure of precision on a percentage scale. The RSE is defined as the standard error of a survey estimate, divided by the survey estimate and multiplied by 100. (Standard error is the square root of the variance.)

Residual Fuel Oil: General classification for the heavier oils that remain after the distillate fuel oils and lighter hydrocarbons are distilled away in refinery operations. Includes Grades No. 5 (Light and Heavy), No. 6 (including heavy-grade, so called Bunker C oil), and Navy Special fuel oil.

Roundwood: Wood cut specifically for use as a fuel.

Short Ton: A unit of weight equal to 2,000 pounds.

Solar Energy: The radiant energy of the sun, which can be converted into other forms of energy, such as heat or electricity.

Standard Industrial Classification (SIC): A set of codes developed by the Office of Management and Budget which categorizes businesses into groups with similar economic activities.

Still Gas (Refinery Gas): Any form or mixture of gas produced in refineries by distillation, cracking, reforming and other processes, the principal constituents of which are methane, hydrogen, ethane, ethylene, propane, propylene, butanes, butylene, etc. Still gas is used for petrochemical feedstock use and refinery fuel use.

Storage Capacity: For the purposes of the MECS, storage capacity includes any capacity that is on the establishment site even if it is dedicated or leased for storage of energy owned by other establishments.

Subbituminous Coal: A dull, black coal of intermediate rank between lignite and bituminous coal. For purposes of the MECS, subbituminous coal, like bituminous coal, is used as a fuel and has approximately 22.012 million Btu per short ton.

Turbine: A machine for generating rotary mechanical power from an energy stream (such as water, steam, or hot gas). Turbines convert kinetic energy to mechanical energy through the principles of impulse and reaction, or a mixture of the two.

Waste Materials: Otherwise discarded combustible materials which, when burned, produce energy for such purposes as space heating and electric power generation. The size of the waste may be reduced by shredders, grinders, or hammermills. Noncombustible materials, if any, may be removed. The waste may be dried and then burned, either alone or in combination with fossil fuels.

Waste Oils and Tar: Petroleum-based materials that are worthless for any purpose other than fuel use; for example, residual byproducts of chemical processes, residue from refining processes, or unsaleable refinery byproducts.

Wind Energy: Energy present in wind motion that can be converted to mechanical energy for driving pumps, mills, and electric power generators. Wind pushes against sails, vanes, or blades radiating from a central rotating shaft.

Wood Waste: Wood byproducts used as a fuel. Included are limb wood, wood chips, bark, sawdust, forest residues, charcoal, and pulp waste.

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